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CONTRIBUTION TO THE FLORA OF THE NEW HEBRIDES

PLANTS COLLECTED BY S. F. KAJEWSKI IN 1928 AND 1929¹

A. GUILLAUMIN

With one text figure

RUBIACEAE

Nauclea sp.

Aneityum: Anelgauhat Bay, rain-forest, alt. 60–450 m., no. 954 (coll. *J. P. Wilson*), Sept. 1929 (tree 12 m. high; diam. 0.5 m.; flowers yellow; fruit light brown, non edible).—Vernacular name “Nepec.”

Uncaria orientalis Guillaumin, sp. nov.—Fig. 4.

Scandens, ramuli tetragoni angulis obtusatis, glabri vel sparse hirtelli, stipulae ovatae (1–1.3 cm. \times 0.5–0.8 cm.), lamina sparsissime hirtella vel glaberrima ad marginem puberula, folia ovato-discoidea (usque ad 11 cm. \times 9 cm.), basi truncato-rotundata, apice subito lineari apice rotundato acuminata, membranacea, rigida vel coriacea, glabra vel infra in costa nervisque et praecipue ad nervorum angulos plus minusve hirtella, nervis 6–7-jugis valde prominentibus, nervis parallelis in venis perpendicularibus non prominentibus sed conspicuis, petiolo 1 cm. longo glabro vel sparse hirtello, uncis magnis compressis ad 3 cm. longis, basi 5 mm. latis glabris vel sparse hirtellis, apice bracteis 3 ovatis 3–4 mm. longis, una aliis duplo (2 mm.) latiore ad marginem puberulis, pedunculo medio articulado bracteolatoque dense piloso vel plus minusve glabro, primum horizontali, postea decurvato, deinde (parte superiore et capitulo delapsis) uncato, capitulo fere 3 cm. diam. ebracteolato, calyce 2 mm. longo, ovario aequilongo dense rufo-velutino, lobis rotundatis tubo 3-plo brevioribus, corolla infundibuliformi fere 1 cm. longa, tubo gracile cylindrico extra dense griseo rufo-velutino intus glaberrimo, lobiis rotundatis 2–3 mm. longis extra rufo-velutinis, intus basin versus linea media longitudinali pilosa excepta, glabris, stigmatibus apice cylindricè dilatato vix exserto.

¹ Continued from Vol. XII, 264 (1931).

Aneityum: Anelgauhat Bay, rain-forest at sea level, no. 910, March 11, 1929 (common vine with sweetly scented, creamy flowers, growing on rain-forest trees). *Eromanga*: Dillon Bay, common in rain-forest, alt. 400 m., no. 348, June 1, 1928 (vine growing on top of trees; used by natives in case of necessity for making fire by rubbing thick part of vine against a hard wood).—Vernacular name "Tevi-cow."



FIG. 4. *UNCARIA ORIENTALIS* Guillaumin ($\times \frac{1}{3}$).

Quite different from the species of New Guinea and the Bismarck Islands which so far have been the most eastern species. It is easy to recognize in these specimens the transformation of the inferior part of the peduncle of the inflorescence into a hook.¹

Dolicholobium aneityense Guillaumin, sp. nov.

Arbor parva, 7 m. alta, ramis primum setulosis deinde glabrescentibus, foliis ovato-lanceolatis (usque ad 14 cm. \times 6 cm.) atroviridibus membranaceis apice acutis basin versus longe attenuatis, supra primum in costa setulosis deinde glabrescentibus, subtus

¹Guillaumin in Compt. Rend. Acad. Sci. Paris, 192, p. 1264(1931).

primum costa, nervis marginibusque setulosis, deinde costa excepta glabrescentibus, nervis 14-16-jugis tenuibus subtus prominentibus, venis tenuissimis, petiolo gracili circa 2 cm. longo setuloso stipulis ellipticis apice rotundatis fere 2 cm. longis setulosis cito caducis; inflorescentia axillaris, cymosa, 4-5 cm. longa, 3-5-flora, floribus albis, pedunculo dense rufo-setuloso circa 1.5 cm. longo, calyx membranaceus, obconicus, 0.5 cm. longus, margine undulatus setulosusque, extra glaber, intus reticulose nervosus et basin versus appresse pilosus, corolla 3.5 cm. longa, tubo gracili cylindrico extra appresse setuloso intus glaberrimo, lobis 5 ovato-falcatis apice obtusis circa 6-7 mm. latis aequilongis, extra marginem versus sparse setulosis, antherae 5, sessiles, ad tubi apicem insertae, lineares, 2.5 mm. longae, apice rotundatae, basi parum sagittatae, tubi orem non attingentes, discus tubulosus, basin styli cingens, stylus gracillimus ad apicem valde dilatatus compressusque, antherarum apicem attingens, lobis 2 apice triangularibus, ovarium pedicello indistinctum, 2-loculare, ovulis in quoque loculo ∞ .

A n e i t y u m : Anelgauhat Bay, common in rain-forest, alt. 450 m., no. 775, Feb. 18, 1929 (small tree up to 6 m. high, with white flowers and dark green leaves).

Related particularly to *D. graciliflorum* Val. of New Guinea and to *D. oblongifolium* A. Gray of the Fiji Islands.

***Badusa occidentalis* Guillaumin, sp. nov.**

Arbor parva, 10 m. alta, ramis viridibus, foliis ovatis vel ovato-lanceolatis (usque ad 15 cm. \times 5 cm.) membranaceis apice breviter obtuseque acuminatis basi cuneatis, nervis 6-8-jugis tenuibus subtus prominulis, venis inconspicuis, petiolo usque ad 2.5 cm. longo, stipulis interpetiolaribus tubulosis breviter mucronatis; inflorescentia corymbosa vel paniculatim corymbosa, foliis fere aequilonga, pedunculo 5-8 cm. longo compresso, bracteis foliaceis ad 2 cm. longis petiolatis, petiolo supra piloso, pedicello 1-1.5 cm. longo gracili apice decurvo, bracteolis triangularibus margine minute erosis supra pilosis, floribus niveis formosissimis, calyx clavatus, apice tubuloso-cupulatus, dentibus 5 minimis margine suberosis, intus velutinus, corolla tubulosa, tubo 5-6 mm. longo, extra glaber, intus medio leviter puberulo lobis 5 recurvis elliptice linearibus apice rotundatis, medio supra longitudinaliter costatis tubo aequilongis, stamina 5, 1.5 cm. longa, filamentis ima basi corollae insertis et tubum brevem formantibus, parte libera dimidio inferiore hispidis, antheris linearibus basi sagittatis, apice obtusis, discus dentibus 5 minimis obtusis circa styli basin, stylus staminibus aequilongus, apice valde clavatus, integerrimus, ovarium 2-loculare, multiovulatum. Fructus clavatus, 1-1.2 cm. longus, tubo calyceino

coronatus, septicide 2-valvis, seminibus valde compressis breviter alatis.

Eromanga: Dillon Bay, common in rain-forest at sea level, no. 393, June 8, 1928 (small tree up to 10 meters, with pretty snow-white flowers).—Vernacular name "Ney in watu."

Only one more species of this genus is known which is restricted to Tonga, while another, *B. philippica* Vidal, non Blanco, remains doubtful.

Oldenlandia Crataegonum Guillaumin in Lecomte, Not. Syst. III. 160 (1915).

Eromanga: Dillon Bay, common in poor, red soil country, alt. 400 m., no. 352, June 1, 1928. Also in New Caledonia.—Vernacular name "Noo lay yelong."

Mussaenda cylindrocarpa Burek in Ann. Jard. Bot. Buitenzorg, III. 118, t. 17 (1883).

Eromanga: Dillon Bay, common in rain-forest, alt. 400 m., no. 349, June 1, 1928 (small tree about 7 m. high with yellow flowers).—Also New Guinea and Bismarck Islands.—Vernacular name "Tear vess."

Mussaenda frondosa Seemann, Fl. Vit., 123 (1886); non Linnaeus.

Aneityum: Anelgauhat Bay, common on seashore, no. 922, March 17, 1929 (small tree up to 9 m. high with brown fruit when ripe).—Already found in *Aneityum*.

Identical with Polynesian specimens (Fiji, Tonga, Wallis, Samoa and Solomon Islands), but different from those of New Caledonia and the Bismarck Islands and also from those of the Caroline Islands which Valetton considers as two distinct species. Merrill has suggested that this may be the same plant as *M. philippica* Rich. of the Philippines.

Chomelia (*Tarenna*) *banksiana* Guillaumin, sp. nov.

Arbor parva, 6 m. alta, ramis cylindraceis, glabris, raro foliatis, folia glaberrima, elliptico-lanceolata, usque ad 19 cm. \times 8 cm., papyracea, basi apiceque acute cuneata, costa infra valde prominente, nervis circa 10-jugis subtus prominulis, petiolo glabro supra leviter sulcato 1.5–4 cm. longo, stipulis brevibus (3–5 mm. longis) glabris apice acutis; inflorescentiae latiores, terminales, foliis multo breviores, ramis minutissime adpresseque setulosis, bracteis linearibus setulosis, floribus albis, pedicello minutissime adpresseque setuloso apice bracteola filiformi minute setulosa munito, calyx turbinatus, haud costatus, lobis bene distinctis rotundatis dense ciliolatis, intus glaber, extra basin versus minutis-

sime adpresseque setulosus, 2 mm. longus, corolla tubo cylindrico lobis longiore extra minute adpresseque puberulo intus medio apicemque versus sparse barbato 5 mm. longo, lobis 5 patulis ellipticis apice rotundatis (3.5 mm. \times 2 mm.) intus glabris extra ut tubus minutissime adpresseque puberulis, stamina 5, fauce inserta, filamentis brevissimis, antheris lineari-lanceolatis basi breviter sagittatis lobis leviter brevioribus, ovarium 2-loculare, quoque loculo 6-ovulato, stylo subulato 1 cm. longo tubi medio sparse barbato. Fructus globosi, 4 mm. diam.

Banks Group: Vanua Lava, common in rain-forest at sea level, no. 470, July 12, 1928 (small tree up to 6 m. high with white flowers).

Remarkable for the distinct rounded lobes of its calyx and the small acute stipules.

Chomelia sp.

Aneityum: Anelgauhat Bay, common in rain-forest alt. 60 m., no. 744, Feb. 12, 1929 (large tree up to 12 m. with black fruit). **Eromanga:** Dillon Bay, common in rain-forest, alt. 300 m., no. 290, May 23, 1928 (small tree up to 8 m.).—Vernacular name "Deuv-yourit."

Randia seziat Guillaumin in Arch. Bot. Mém. III. no. 5, 9 (1930).

Aneityum: Aname, common on seashore along w. coast, alt. 30 m., no. 991 (coll. *J. P. Wilson*) Sept. 1929 (small tree 15 cm. diam. with white flowers and brown fruit).—Also New Caledonia and Loyalty Islands.—Vernacular name "Daramdaram."

Gardenia tannaensis Guillaumin, sp. nov.

Arbor parva, 6 m. alta, foliis lanceolatis (usque ad 28 cm. \times 8.5 cm.) apice basique acutis rarius apice rotundatis basi cuneatis, membranaceis, nervis 7-15-jugis, subtus prominentibus, venis numerosis, stipulis lanceolatis vel deltoideis 1 cm. longis basi tubum 0.5 cm. longum formantibus, petiolo 1.5-2 cm. longo, gemmis resinosis, flores solitarii, breviter pedicellati, calyce obconico extra glabro, lobis 5, 1.5 cm. longis falciformibus acutis brevissime puberulis, corollae tubo sepalis aequilongo extra brevissime puberulo, lobis 5 tubo aequilongis.

Tanna: Lenakel, very rare in rain-forest soil, alt. 100 m. no. 33, Feb. 21, 1928 (small tree about 6 m.).

Gardenia sp.

Eromanga: Dillon Bay, common in rain-forest at sea level, no. 362, June 4, 1928 (shrub about 4 m. high with white flowers and with leaves which are used for healing by being placed on wound after being heated and rubbed).—Vernacular name "Neace ya vot."

Gardenia sp.

Aneityum : Anelgauhat Bay, common in rain-forest, alt. 180 m., no. 913, March 17, 1929 (small tree up to 6 m. high, with yellow fruit).

This and the preceding species resemble each other in their falciform calyx-lobes.

Gardenia sp.

Banks Group : Vanua Lava, common in rain-forest at sea level, no. 489, July 17, 1928 (small tree up to 8 m. high).

Gardenia sp., *praecedenti affinis*.

Eromanga : Dillon Bay, common in rain-forest, alt. 300 m., no. 369, June 5, 1928 (large tree up to 20 m. high).—Vernacular name "Nor-rooka."

These different species belong to the group with well developed calyx-lobes, not abundant in New Guinea, but well represented in New Caledonia.

Guettarda speciosa Linneaus, Sp. Pl. 991 (1753).

Aneityum : Anelgauhat Bay, common on seashore, no. 799, Feb. 21, 1929 (tree 9 m. high; flowers white, sweetly scented). **Efate** : Undine Bay, common in rain-forest along sea shore, no. 210, April 25, 1928 (tree up to 20 m.; flowers white to cream). **Eromanga** : Dillon Bay, common in rain forest along sea shore, no. 363, June 4, 1928 (large tree up to 20 m. high).—Already found in Efate; also in New Caledonia, Australia (Queensland, North Australia), Fiji, Samoa, Cook, Society, Union, Ellice, Gilbert, Marshall, Caroline, Mariana, Solomon, Bismarck and Admiralty Islands, New Guinea and Malaysia.—Vernacular name "Ou-ven-ou-ven."

Guettarda Kajewskii Guillaumin, n. sp.

Arbor mediocris, 5 m. alta, foliis obovatis (usque ad 11 cm. \times 6 cm.) atro-viridibus membranaceis basi cuneatis apice breviter obtusissimeque acuminatis, nervis 5–8-jugis valde tenuibus parum conspicuis, venis inconspicuis, petiolo ad 1.5 cm. longo, stipulis lanceolatis acutis 2–3 mm. longis extra adpresse argenteo-puberulis, citissime, caducis, inflorescentiae densius cymosae, 1.5–3 cm. longae, pedunculo leviter compresso subglabro, floribus subflavis minutis, bracteis ovato-deltaideis minimis, calyx poculiformis, edentatus, corolla 4–5 mm. longa, tubo cylindrico extra praecipue basin versus argenteo-puberulo, lobis 5 rotundatis 2 minoribus (an semper?), stamina 5, fauce inserta, sessilia, leviter exserta, antheris linearibus 3 mm. longis.

Aneityum : Anelgauhat Bay, common in rain-forest, alt.

30 m., no. 724, Feb. 11, 1929 (medium sized tree up to 12 m.; leaves dark green; corolla cream-colored).

Guettarda sp.

Aneityum: Anelgauhat Bay, common in rain-forest, alt. 210 m., no. 826, Feb. 28, 1929 (medium sized tree up to 9 m. high; wood hard; fruit purple when ripe).

Plectronia odorata (Forst.) Hillebrand, Fl. Hawaii Isl. 175 (1888).

Aneityum: Anelgauhat Bay, common in rain-forest, alt. 30 m., no. 726, Feb. 11, 1928 (tree up to 12 m. high; fruit yellow when ripe). *Efafe*: Undine Bay, common in rain-forest, alt. 30 m., no. 191, April 23, 1928 (tree up to 20 m. high; fruit greenish purple when ripe).—Already found on Tanna; also New Caledonia, Loyalty, Fiji, Tonga, Society and Marquesas Islands.—Vernacular name "Toolepau" (under no. 191).

Plectronia sp. affinis *P. barbata* K. Schum.

Tanna: Mt Tokosh Meru, common in rain-forest, alt. 300 m., no. 170, March 15, 1928 (tree about 20 m. high).

Ixora aneityensis Guillaumin, sp. nov.

Arbor parva, 7 m. alta, ramis sat magnis ut gemmis roseis, foliorum delapsorum cicatricibus valde prominentibus, foliis sessilibus lanceolatis (usque ad 30 cm. \times 8.5 cm.) apice attenuatis basi auriculatis rigide membranaceis, costa subtus valde prominente, nervis 13-jugis subtus prominentibus, venis reticulatis subtus prominulis, stipulis fere 7 cm. longis triangularibus carinatis apice 3 mm. longe caudato-acuminatis, inflorescentia terminalis, 7 cm. longa, paniculata, ramis brevissime puberulis, bracteis triangularibus longe caudato-acuminatis vel deficientibus, floribus albo-roseis pedicello 3–8 mm. longo vulgo apice subulate bracteolato brevissime puberulo suffultis, calyx ovatus, extra minute puberulus, 3 mm. longus, lobis 4 acutis brevissimis, corolla ad 2.5 cm. longa, lobis 4 lanceolatis extra subglabris tubo cylindrico extra minute puberulo leviter brevioribus, stamina 4, fauce inserta, filamentis brevibus, antheris acutissime lanceolatis basi sagittatis 6 mm. longis, stylus gracilis, apice fusiformis, antherarum apicem attingens.

Aneityum: Anelgauhat Bay, common in rain-forest, alt. 300 m., no. 851, March 2, 1929 (small tree up to 6 m. high; flowers pink-white, with pink buds and stems).

This approaches especially *I. montana* Schlechter of New Caledonia, but the leaves and the calyx are very different.

Pavetta opulina De Candolle, Prodr. iv. 492 (1830).

Aneityum: Anelgauhat, common in lower ranges, alt. 300 m., no. 969 (coll. *J. P. Wilson*), Sept. 1929 (small tree; flowers small, white; fruit a cluster of brown berries). *Efate*: Fila Island, Vila, common in rain-forest along sea coast, no. 187, April 14, 1928 (small tree 5 m., flowers white).—Already recorded from Eromanga; also in New Caledonia and Loyalty Islands.—Vernacular name “Natge” (under no. 969).

Pavetta sambucina De Candolle, Prodr. iv. 492 (1830); non *Tarenna sambucina* K. Schum.

Tanna: Lenakel, common in rain-forest soil, alt. 100 m., no. 30, Feb. 21, 1928 (shrub up to 5 m.; flowers white).—Also in Fiji and Society Islands.

These two species, extremely close, seem to me hardly distinct from the var. *tomentosa* Hook. f. of New Guinea and Malaysia.

Coffea arabica Linnaeus, Sp. Pl. 172 (1753).

Eromanga: Dillon Bay, common, growing wild in rain-forest at sea level, no. 368, June 5, 1928 (common shrub gathered to see if any difference takes place when it grows wild).

Morinda citrifolia Linnaeus, Sp. Pl. 176 (1753).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 709, Feb. 9, 1928 (small tree up to 10 m. high; petals white; fruit cream-colored when ripe, 5.5 cm. long, 4 cm. in diam.). *Eromanga*: Dillon Bay, common in rain-forest at sea level, no. 260, May 15, 1928 (small tree up to 10 m. high; fruit cream-colored; sap of root used by natives as a red dye for grass skirts).—Already found in Efate; also New Caledonia, Loyalty Islands, Australia (Queensland, North Australia), Fiji, Tonga, Samoa, Cook, Society, Marquesas, Union, Ellice, Marshall, Caroline, Mariana, Hawaii, Solomon, Bismarck and Admiralty Islands, New Guinea and Malaysia.—Vernacular name “Noah-i-rat.”

Morinda Forsteri Seemann, Fl. Vit. 129 (1866).

Aneityum: Anelgauhat Bay, common in rain-forest at 30 m., no. 725, Feb. 11, 1929 (vine climbing up the rain-forest trees; fruit dark purple when ripe).—Also New Caledonia, Loyalty, Fiji, Tonga, Samoa, Pitcairn, Gambier and Mariana Islands.

Calycosia Milnei A. Gray in Proc. Am. Acad. iv. 307 (1860).

Aneityum: Anelgauhat Bay, common in rain-forest at 180 m., no. 817, Feb. 28, 1929 (small tree up to 6 m. high; flowers white; fruit orange-colored when ripe, 2 cm. long, 1.5 cm. in diam., slightly flattened at each end). *Tanna*: Mt. Tokosh Meru, common in rain-forest at 800 m., no. 162, March 15, 1928 (small tree up to 8 m. high; flowers white). *Eromanga*: Dillon Bay,

common in rain-forest at 400 m., nos. 315 and 315A, May 28, 1928 (small tree up to 7 m. high; flowers white; fruit red).—Already found on Aneityum; also Fiji Islands.—Vernacular name "Ney-in-war-tu."

Calycosia sp.

E r o m a n g a : Dillon Bay, alt. 300 m., rain-forest, common, no. 402, June 8, 1928 (small tree, 10 m. high; fruit red when ripe).—Vernacular name "Nem-pel-ted."

Psychotria aneityensis Guillaumin, sp. nov.

Frutex glaberrimus, 4 m. altus, ramis gracilibus viridibus, foliis glabris lanceolatis (usque ad 10 cm. \times 3 cm.) apice acutis basi anguste attenuatis membranaceis, nervis 8–12-jugis tenuissimis, petiolo 1–2 cm. longo, stipulis brevissimis deltoideis apice mucronulatis, inflorescentia axillaris vel pseudo-terminalis, cymose umbellata, 2 cm. longa, pedunculo gracili, floribus subflavis, 3–5-nis, pedicello capillari circa 5 mm. longo, bracteis minutissimis, calyx hypocrateriformis, 1 mm. longus, lobis indistinctis, corolla 2 mm. longa, campanulata, lobis ovatis tubo fere 2-plo brevioribus, stamina inclusa, sub fauce inserta, filamentis brevibus, antheris 0.5 mm. longis linearibus apice truncatis basi leviter sagittatis, discus epigynus, tubulosus, stylus antheras leviter superans, basi gracili, apice dilatato, ramis 2 apice truncatis. Fructus pedicello circa 1 cm. longo suffultus, 6–7 mm. longus, pyrenis longitudinaliter sulcatis.

A n e i t y u m : Anelgauhat Bay, common in rain-forest at 30 m., no. 733, Feb. 11, 1929 (shrub up to 3.5 m. high; flowers cream-colored).

Psychotria nacdado Guillaumin, sp. nov.

Scandens, ramis rubris, foliis glabris ovato-lanceolatis (usque ad 14 cm. \times 5 cm.) apice acute acuminatis basi cuneatis membranaceis, nervis circa 9-jugis tenuibus subtus tantum prominulis vel immersis, petiolo 1.5–2 cm. longo, stipulis citissime caducis, axillis puberulis, inflorescentia terminalis, pyramidalis-paniculata, usque ad 5 cm. longa et 7 cm. lata, multiflora, floribus albis, pedicello 2–3 mm. longo dense papilloso, calyx campanulatus, 1.5 mm. longus, sparse papillosus, dentibus minutis triangulari-acutis, corolla infundibuliformis, usque ad 7 mm. longa, lobis lanceolatis apice intus leviter uncinatis, tubo extra praecipue basin versus dense papilloso intus dimidio superiore dense barbato, lobis extra sparse papillosis intus glabris, stamina exserta, fauce inserta, filamentis antheris fere 2-plo longioribus, antheris 1 mm. longis linearibus apice basique truncatis, discus epigynus, tubulosus, stylus antheris aequilongus, apice dilatatus 2-fidusque. Fructus nigris.

Aneityum: Anelgauhat Bay, common in lower hills up to 300 m., no. 979 (coll. *J. P. Wilson*), Aug. 1929 (vine covering trees; leaves medium; flowers small white, in clusters; fruit small black berries). *Banks Group*: Vanua Lava, common in rain-forest at 500 m., no. 485, July 16, 1928 (vine climbing over rain-forest trees; flowers white).

This species is fairly close to *P. rupicola* Schlechter of New Caledonia.—Vernacular name "Nacdado" (under no. 979).

***Psychotria* sp.**

Banks Group: Vanua Lava, not common in rain-forests up to 100 m., no. 411, June 5, 1928 (small tree up to 10 m. high).

***Psychotria* sp.**

Aneityum: Anelgauhat Bay, sea level, sea shore, common, no. 926, March 17, 1929 (small tree, 7 m. high; leaves dark glossy green; fruit 8 mm. long, 6 mm. diam., red when ripe).

COMPOSITAE

***Vernonia cinerea* (L.) Lesser in Linnaea, iv. 291 (1829).**

Eromanga: Dillon Bay, common in rain-forest clearings at 300 m., no. 384, June 8, 1928 (common weed throughout the Island).—Already found on *Aneityum*, *Erronan*, *Tanna* and *Eromanga*; also *New Guinea*, *Bismarck*, *Solomon*, *Fiji*, *Samoa*, *Cook*, *Marshall*, *Caroline* and *Mariana Islands*, *New Caledonia*, *Australia* (*Queensland*, *North Australia*, *New South Wales*), *Moluccas* and *Malaysia*.—Vernacular name "Sow-any-longa."

***Ageratum conyzoides* Linnaeus, Sp. Pl. 839 (1753).**

Eromanga: Dillon Bay, common in cleared rain-forest at 300 m., no. 382, June 8, 1928 (very common weed throughout the group).—Already found in *Aneityum*, *Erronan* and *Tanna*; also *New Caledonia*, *Australia* (*Queensland*), *Norfolk Islands*, *New Zealand*, *Fiji*, *Samoa*, *Cook*, *Marquesas*, *Marshall*, *Caroline*, *Bismarck* and *Solomon Islands*, *New Guinea*, *Moluccas* and *Malaysia*.—Vernacular name "Ou lakkidine."

***Blumea densiflora* De Candolle, Prodr. v. 446 (1836).**

Efate: Undine Bay, common in rain-forest at 200 m., no. 215, April 27, 1928 (about 2 m. high growing in clearings; flowers yellow).—Also *New Caledonia*, *Fiji* and *Bismarck Islands*, *New Guinea* and *Malaysia*.

***Wedelia aristata* Lesser in Linnaea, vi. 160 (1831).**

Wedelia biflora De Candolle in Wight, Contrib. Bot. India, 18 (1834).

Efate: Undine Bay, common in rain-forest soil of cocoanut

plantation at sea level, no. 196, April 24, 1928 (up to 3 m. high; flowers yellow; leaves used by natives to give flavor to fish). **Banks Group**: Vanua Lava, common in cleared rain-forest land at sea level; no. 460, July 12, 1928 (up to 2 m. high; flowers bright yellow; a troublesome weed).—Already found on Aneityum, Tanna, Eromanga and Efate; also New Caledonia, Loyalty Islands, Australia (Queensland, New South Wales, North Australia), Norfolk, Fiji, Tonga, Wallis, Samoa, Ellice, Marshall, Caroline, Mariana and Solomon Islands, New Guinea, Malaysia.

GOODENIACEAE

Scaevola cylindrica Schlechter & Krause in Engler, Pflanzenr. iv.—277, p. 129 (1912).

Aneityum: Anelgauhat Bay, common in poor red soil country, no. 911, March 11, 1929 (bush up to 3 m. high; flowers white, sweetly scented). **Eromanga**: Dillon Bay, common in red soil of poor bracken country, at 300 m., no. 293, May 23, 1928 (flowers white).—Also New Caledonia.—Vernacular name "Wibe Wibe" (under no. 293).

Scaevola frutescens (Mill.) Krause in Engler, Pflanzenr. iv.—277, p. 125 (1912).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 786, Feb. 19, 1929 (common shrub up to 5 m. high, growing along the sea shore; flowers white; fruit white when ripe, 0.75 cm. long, 1 cm. in diam.).—Already found on Efate; also New Caledonia, Loyalty Islands, Australia (Queensland, North Australia), Fiji, Tonga, Santa Cruz, Samoa, Cook, Society, Paumotu, Union, Ellice, Gilbert, Marshall, Caroline, Mariana, Hawaii, Solomon, Bismarck and Admiralty Islands, New Guinea, Malaysia.

VACCINIACEAE

Vaccinium Macgillivrayi Seemann in Jour. Bot. ii. 77 (1864).

Aneityum: Anelgauhat Bay, common in poor red soil country at 60 m., no. 701, Feb. 4, 1929 (shrub up to 4 m. high; petals white, stamens yellow; fruit purple when ripe, eaten by the natives). **Eromanga**, Dillon Bay, common in poor red soil of bracken country at 300 m., no. 301, May 24, 1928 (small shrub about 3 m. high; fruit black, 1.25 cm. long, 1 cm. in diam., eaten by the natives).—Already found on Aneityum.—Vernacular name "Autarm-tell" (under no. 301).

EPACRIDACEAE

Leucopogon cymbulae Labillardière, Sert. Austro-Caled. 36, t. 39 (1824).

Aneityum: Anelgauhat Bay, common in rain-forest at 50 m., no. 702, Feb. 4, 1929 (crooked tree up to 10 m. high, growing in gullies; corolla white). **Eromanga**: Dillon Bay, common in poor red soil of bracken country at 400 m., no. 351, June 1, 1928 (shrub up to 3 m. high; leaves bound to a pole are used as brooms).—Already found on Aneityum; also New Caledonia, Fiji Islands.—Vernacular name “Nom-pul-low” (under no. 351).

MYRSINACEAE

Maesa efatensis Guillaumin in Bull. Soc. Bot. France, LXVI. 272 (1920).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 792, Feb. 20, 1929 (small tree up to 6 m. high; fruit pink-cream when ripe, 0.5 cm. long, 0.7 cm. in diam.). **Tanna**: Lenakel, common in heavy rain-forest soil at sea level, no. 9, Feb. 20, 1928 (tree up to 20 m. high, dark green with brown veins underneath).—Already found on Efate.

Rapanea modesta Mez in Engler, Pflanzenr. iv. 236, p. 367 (1902).

Efate: Undine Bay, common in rain-forest at 200 m., no. 237, April 28, 1928 (small tree up to 12 m. high; fruit purple when ripe; wood pink when freshly cut).—Also in New Caledonia.

Rapanea sp.

Aneityum: Anelgauhat Bay, common in rain-forest at 60 m., no. 751, Feb. 12, 1929 (large tree up to 12 m. high; leaves dark green with light yellow midrib; fruit black when ripe, 1 cm. long, 0.75 cm. in diam.).

Tapeinosperma Kajewskii Guillaumin, sp. nov.

Ramulis gracilibus (3 mm. diam.) primum sparse tomentellis, deinde glaberrimis, foliis obovatis (usque ad 14 cm. \times 5.5 cm.) apice obtusis basi longe attenuatis sessilibus rigide membranaceis nervis a venis subtus reticulatis parum distinctis, punctis nigris minimis; inflorescentiae 2–3 cm. longae, ad ramulorum apicem congestae, ramis 2–3 rubiginosis et nigro lineatis leviter furfuraceis vel glabris, pedicellis 2 mm. longis, floribus 3 mm. longis sordide roseo-purpureis, sepalis ovatis apice obtusis basi tantum coalitis, margine furfuraceo-ciliatis, petalis late ovatis apice rotundatis basi $\frac{1}{3}$ coalitis bene punctatis, staminibus petalis minoribus, antheris late ovatis epunctatis, filamentis nullis, ovario ovoideo, stylo bene distincto, stigmatibus peltatis discoideo. Fructus globosi (1.2 cm. diam.), apice umbonati, longitudinaliter brunneo-lineati.

Aneityum: Anelgauhat Bay, common in rain-forest at 210 m., no. 822, Feb. 28, 1929 (petals a dirty pink-purple with small

purple spots on the outside; fruit 1 cm. long, 1 cm. in diam. with elongated brown spots).

Tapeinosperma netor Guillaumin, sp. nov.

Arbor parva (ultra 7 mm.) vel alta (30 m.), ramulis sat gracilibus (circa 5 mm. diam.) glaberrimis, foliis lanceolatis (usque ad 20 cm. x 5 cm.) apice acutis basi in petiolum circa 1 cm. longum longe attenuatis membranaceis, nervis 16-19-jugis, tenuissimis immersis creberrime punctatis, inflorescentiae 8-9 cm. longae, graciles, ad ramulorum apicem congestae, pinnatim paniculatae, pedicellis circa 0.5 cm. longis, floribus 3 mm. longis, sepalis ovatis apice rotundatis tertia infima parte coalitis margine rigida breviterque ciliatis, petalis roseis ovatis apice obtusis basi $\frac{1}{5}$ tantum coalitis apice manifeste punctatis basi lineatis, staminibus petalis minoribus, antheris ovatis dorso valde punctatis, filamentis brevibus, ovario subulato. Fructus maturitate rubri, 1.5 cm. diam.

A n e i t y u m : Anelgauhat Bay, common in rain-forest at 240 m., no. 768, Feb. 12, 1929 (small tree up to 6 m. high; fruit red when ripe, very similar to shape of a cherry, 1 cm. long, 2 cm. in diam.). **E r o m a n g a** : Dillon Bay, common in rain-forest at 400 m., no. 313, May 28, 1928 (tree up to 30 m. high, growing about 6 miles inland among very tall rain-forest trees; petals pink).—Vernacular name "Net-or" (under no. 313).

These two species are rather closely related though they can be distinguished at the first glance; they are near *T. grande* Mez of the Fiji Islands.

SAPOTACEAE

Sideroxylon (Planchonella) **aneityense** Guillaumin, sp. nov.

Arbor 15-20 m. alta, ramis gracilibus primum sparse rufo-pilosis cito glabris, cortice brunneo abunde longitudinaliter striolato, gemmis rufo-pilosis, foliis lutescentibus membranaceis lanceolatis (usque ad 10 cm. x 3.5 cm.) utrinque glabris apice acutis basin versus longe attenuatis, nervis 7-9-jugis a venis reticulatis parum distinctis, petiolo gracili 1-2 cm. longo. Flores albo-virides, graveolentes, in axillis supremis dense fasciculati, pedicellis tenuibus ad 1 cm. longis sparse rufo-pilosis, calycis segmentis ovatis 1 mm. longis apice rotundatis extra sparse rufo-pilosis, corollae tubo 1 mm. longo lobis ovatis aequilongo, staminodiis filiformi-subulatis, staminibus filamentis sub fauce insertis, antheris ovatis aequilongis, ovario breviter lateque conico dense rufo-lanuginoso, stylo brevissimo cylindrico glabro.

A n e i t y u m : Anelgauhat Bay, common in rain-forest at 300 m., no. 771, Feb. 14, 1929 (large tree up to 15 m. high; leaves light

green; petals greenish white, sweetly scented); common in rain-forest at 300 m., no. 945, March 19, 1929 (large tree up to 18 m. high; fruit immature; wood durable).—Vernacular name "Inretchar" (under no. 945).

Near *S. acutum* Krause of New Guinea.

Sideroxylon (Planchonella) **tannaense** Guillaumin, sp. nov.

Arbor 5 m. alta, trunco 75 cm. diam., ramis sat validis cinereis, foliis membranaceis ovatis (usque ad 15 cm. x 7 cm.) utrinque glabris apice valde obtusis basin versus cuneatis, nervis circa 9-jugis gracilibus a venis reticulatis parum distinctis, petiolo usque ad 4 cm. longo. Flores minimi, trunco circa 5-ni-fasciculati, pedicellis tenuibus 6–7 mm. longis tomentosis, calycis segmentis ovatis, 1 mm. longis dorso dense tomentosis, corollae tubo lobis brevior, lobis ovatis 1 mm. longis apice rotundatis, staminodiis filiformi-subulatis, staminum filamentis sub fauce insertis, antheris ?, ovario depresso globoso dense rufo-tomentoso, stylo conico glabro.

Tanna: Lenakel, common in rain-forest at 200 m., no. 104, March 6, 1928 (tree up to 15 m. high, 75 cm. in diam.; fruit eaten by natives or so reported).

Near *S. novo-guineense* K. Schum. of New Guinea and perhaps also of the Moluccas.

Sideroxylon sp.

Aneityum: Anelgauhat Bay, common in rain-forest at 150 m., no. 936, March 17, 1929 (large tree up to 15 m. high; leaves dark green; fruit immature; a good commercial timber for wood not exposed to weather). **Eromanga:** Dillon Bay, common in rain-forest at 300 m., no. 385, June 8, 1928 (large tree up to 25 m. high with a very hard wood; leaves light brown underneath).—Vernacular name "Ney-mor" (under no. 385).

Sideroxylon sp.

Aneityum: Anelgauhat Bay, common in rain-forest at 300 m., no. 941, March 19, 1929 (large tree up to 15 m. high; fruit immature).

Sideroxylon sp.

Eromanga: Dillon Bay, common in poor red soil, bracken country, at 300 m., no. 298, May 24, 1928 (small shrub up to 5 m. high; fruit purple when ripe).—Vernacular name "Nor-sum."

Mimusops parvifolia R. Brown, Prod. Fl. Nov. Holl. I. 531 (1810).

Aneityum: Anelgauhat Bay, common in rain-forest at 30 m., no. 730, Feb. 11, 1929 (large tree up to 6 m. high; flower white; young stems covered with brown hair). **Eromanga:** Dillon

Bay, common in rain-forest at 150 m., no. 266, May 17, 1928 (tree up to 20 m. high; fruit light red, bark rough and fissured). *E f a t e*: Fila Island, Vila, common in rain-forest at sea level, no. 179, April 12, 1928 (tree about 15 m. high reputed by natives to be poisonous).—Also New Caledonia, Loyalty Islands, Australia (Queensland, North Australia), and New Guinea.—Vernacular name “Yatarhwu” (under no. 266).

Manilkara dissecta (R. Br.) Dubard in Ann. Mus. Colon. Marseille, sér. 3, III. 13 (1915).

A n e i t y u m: Anelgauhat Bay, scarce in the lower hills at 150 m., no. 983 (coll. *J. P. Wilson*), Sept. 1929 (large tree up to 1.30 m. in diam.; leaves small, elongated; flowers pink; fruit small, brown, only on extreme tips of branches; timber very hard, dark red, too scarce to be of commercial value); common in the rain-forest at 150 m., no. 937, March 17, 1929 (large timber tree up to 21 m. high; fruit immature; one of the best durable hard timbers on the island).—Also Tonga Islands.—Vernacular name “Niping.”

Palaquium neo-ebudicum Guillaumin, sp. nov.

Arbor 25 m. alta, ramis validis primum rubiginoso-villosis deinde glabris, foliis rigide membranaceis ovatis (usque ad 12 cm. x 7 cm.) primum rubiginoso vestitis deinde glabris apice rotundatis basi cuneatis, petiolo 2.5–3.5 cm. longo, nervis 9–10-jugis bene distinctis, venis oblique parallelis. Flores ad ramulorum apicem, infra folia, dense fasciculati, pedicellis 1.5–3.5 cm. longis rubiginosotomentosis, calycis lobis ovatis, exterioribus 4 mm. longis, interioribus duplo brevioribus dorso rubiginoso-vestitis, corollae glabrae tubo brevi, lobis oblongis obtusis, antheris fere sessilibus anguste lanceolatis, dorso dense rubiginoso-pilosis, ovario glabro, stylo subulato valde elongato.

A n e i t y u m: Anelgauhat Bay, common in rain-forest at 60 m., no. 756, Feb. 13, 1929 (large tree up to 18 m. high; outside of flower-buds covered with brown hairs). *E r o m a n g a*: Dillon Bay, common in rain-forest at 400 m., center of the island, no. 344, June 1, 1928 (large tree up to 25 m. high; heart wood yellowish brown).—Vernacular name “Ney-more-yetu” (under no. 344).

Bassia Kajewskii Guillaumin, sp. nov.

Arbor ultra 20 m. alta, trunco 35–45 cm. diam., ramis crassis, foliis obovatis (usque ad 15 cm. x 9 cm.) atro-viridibus pergamentaceis apice rotundatis basi sensim cuneatis, nervis 10–12-jugis validis cum totidem intermediis, venis reticulatis, petiolo valido 1.5 cm. longo. Flores terminales fasciculati, pedicellis 1 cm. longis gracilibus appresse pilosis, calycis laciniis oblongis apice obtusis

extra dense appresse pilosis 3 mm. longis, corollae tubo 1 mm. longo lobis ovatis fere aequilongo glaberrimo, staminibus 16, antheris fere sessilibus anguste sagittatis, connectivo intus extraque dense lanuginoso, ovario conico stylo tereti coronato.

Tanna: Lenakel, common in rain-forest soil at 150 m., no. 43, Feb. 23, 1928 (tree up to 20 m. high, 35–45 cm. in diam.; leaves dark green above, light green underneath; sap milky; fruit eaten by the natives).

Near **B. bawun** (Scheff.) Guillaumin, comb. nov., of New Guinea.

Bassia obovata Forster, Fl. Ins. Austr. Prod. 35 (1786).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 804, Feb. 21, 1929 (large tree up to 18 m. high; leaves dark green; flowers white; fruit light green up to 11.5 cm. long, flesh white inside, seeds large, black; fruit very luscious, eaten by the natives). **Banks Group:** Vanua Lava, common in rain-forest at 100 m., no. 464, July 10, 1928 (large tree up to 20 m. high; flowers cream-colored; fruit eaten by the natives).—Already found on Tanna and Efate.

Bassia sp., affinis *B. obovata* Forst.

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 833, Feb. 1, 1929 (large tree up to 12 m. high; fruit brown, immature on specimens; wood durable).

SAPOTACEARUM GEN.?

Aneityum: Anelgauhat Bay, common in rain-forest at 150 m., no. 935, March 17, 1929 (large tree up to 18 m. high; leaves dark glossy green; fruit immature, covered with dense brown hairs).

EBENACEAE

Maba buxifolia Persoon, Syn. Pl. II. 606 (1807).

Erromanga: Dillon Bay, common in rain-forest at 300 m., no. 391, June 8, 1928 (tree up to 15 m. high; natives say fruit is red when ripe; kernel of the nut is eaten by natives). **Aneityum:** Anelgauhat Bay, common in rain-forest at 150 m., no. 932, March 17, 1929 (medium-sized tree up to 15 m. high; fruit immature; wood used for native houses).—Also New Caledonia, Loyalty, Tongo and Caroline Islands, New Guinea, Malaysia.—Vernacular name “Ni-Mung-lei” (under no. 391).

SYMPLOCACEAE

Symplocos aneityensis Brand in Engler, Pflanzenr. IV.-242, p. 39, (1901).

Aneityum: Anelgauhat Bay, common in rain-forest at sea

level, no. 720, Feb. 11, 1929 (large tree up to 18 m. high; flowers white; wood used by natives for canoe paddles). *Eromanga*: Dillon Bay, common in poor red soil, bracken country, at 300 m., no. 295, May 24, 1928 (tree up to 10 m. high; flowers white; wood used in making paddles for canoes; this tree is found 4 or 5 miles inland).—Already found in Aneityum.—Vernacular name “More-lease” (under no. 295).

OLEACEAE

Jasminum didymum Forster, Fl. Ins. Austr. Prod. 3 (1786).

Eromanga: Dillon Bay, common in rain-forest at sea level, no. 259, May 15, 1928 (fruit black when ripe; used by natives as rope or cordage for binding their houses as it lasts a long time).—Already found on Efate; also New Caledonia, Loyalty Islands, Australia (Queensland, North Australia), Fiji, Tonga, Samoa, Cook and Society Islands, New Guinea.—Vernacular name “No-sori.”

Jasminum simplicifolium Forster, Fl. Ins. Austr. Prod. 3 (1786).

Eromanga: Dillon Bay, common in rain-forest at 300 m., no. 404, June 8, 1928 (vine growing up to the tops of rain-forest trees; fruit black when ripe).—Already found on Aneityum; also New Caledonia, Loyalty Islands, Australia (Queensland, New South Wales, North Australia), Norfolk, Fiji, Tonga and Samoa Islands.—Vernacular name “No-sori.”

APOCYNACEAE

Melodinus neo-ebudicus Guillaumin, sp. nov.

Alte scandens, ramis gracilibus 2 mm. diam. rubris, foliis oppositis lanceolatis (usque ad 9 cm. x 3 cm.) membranaceis integris apice longe acuminatis basi obtusis, nervis tenuibus crebris parallelis, petiolo gracili ad 4 mm. longo. Inflorescentiae axillares, cymosae, 3–5-florae, 1.5–3.5 cm. longae, pedicellis gracilibus usque ad 3 mm. longis apice 2-bracteolatis, sepalis 5 ovatis obtusis 1 mm. longis, corollae tubo roseo 5 mm. alto extra glabro intus tertia infima parte glabra, media sparse pilosa, suprema dense barbata, lobis 5 patulis ovatis (4 mm. x 2 mm.) albis, staminibus 5 anguste lanceolatis 1 mm. longis sessilibus ad $\frac{2}{3}$ tubi insertis, ovario anguste ovoideo apice attenuato, stylo tereti gracili stigmatum conico apice 2-aristato inclusis 3 mm. longo. Fructus globosus 2 cm. diam. maturitate luteus, sicco atro-rubro-brunneus, pruinosis.

Aneityum: Anelgauhat Bay, common in rain-forest at 30 m., no. 729 (type of the flower), Feb. 11, 1929 (vine growing over rain-forest trees; petals white, corolla stem [? tube] pink). *Eromanga*: Dillon Bay, common in rain-forest at 300 m., no. 392 (type of

fruit), June 8, 1928 (vine growing over rain-forest trees; fruit yellow when ripe).

To be placed near *M. buxifolius* Baill. and *M. celastroides* Baill. of New Caledonia which probably constitute only one species.—Vernacular name “Nosarak” (under no. 392).

Alyxia efatensis Guillaumin, sp. nov.

Alte scandens, ramis sat crassis, foliis 3-nis lanceolatis (usque ad 10 cm. x 3.5 cm.) rigide membranaceis apice obtusis vel acutis rarissime acuminatis basi cuneatis, venis immersis tenuibus crebis fere rectis, petiolo circa 1 cm. longo. Inflorescentiae ad ramulorum apicem axillares, ad 5 cm. longae, umbellatim cymosae, foliis 2 parvis (2.5–3 cm. x 0.9–1 cm.) oppositis, apice bracteatae, floribus luteis 3 in pedunculo communi 5 mm. longo sessilibus vel 5 exterioribus pedicello 2.5 mm. longo suffultis, tantum inapertis 2 cm. longis, bracteola 1 lanceolata ima calycis basi, sepalis 5 lanceolatis 2.5 mm. longis apice molliter ciliolatis, corollae tubo 1.2 cm. longo cylindrico apice leviter strangulato et intus sub staminibus breviter barbato, lobis brevibus (5 mm. longis) anguste ovatis, staminum filamentis antheris 2-plo brevioribus sub fauce insertis, antheris tubi apicem attingentibus, locis fere parallelis apice obtuse mucronatis, ovario conico apice attenuato, stylo longo staminum basin attingente tereti apice leviter dilatato (?).

E f a t e: Undine Bay, common in rain-forest at 500 m., no. 231, April 28, 1928 (vine climbing up to tops of rain-forest trees; flowers yellow).

The most closely related species, though differing in its pubescent ovary seems to be *A. laurina* Gaudich. from the islands Rawak and Gebeh of the Moluccas.

Alyxia, sp. nov.?

B a n k s G r o u p: Vanua Lava, common in rain-forest at 300 m., no. 477, July 12, 1928 (vine growing over rain-forest trees).

Cerbera manghas Linnaeus, Sp. Pl. 208 (1753).

A n e i t y u m: Anelgauhat Bay, common in rain-forest at sea level, no. 806, Feb. 21, 1929 (common scrub tree up to 12 m. high; flowers sweetly scented, petals dirty brown with white edges; fruit 9 cm. long, 5.5 cm. in diam., purple when ripe).—Already found on Tanna and Efate; also New Caledonia, Loyalty, Fiji, Tonga, Samoa, Society, Marquesas, Gambier, Marshall, Caroline, Mariana, Solomon, Bismarck and Admiralty Islands, New Guinea, Aru Islands and Malaysia.

Ochrosia alyxioides Guillaumin, sp. nov.

Arbor parva, 7 m. alta, lactescens; ramis gracilibus, foliis 3–4-nis

rigide membranaceis linearibus (usque ad 12 cm. x 1 cm.) apice attenuatis basi longe attenuatis, nervis immersis creberrimis rectis, petiolo circa 1 cm. longo gracile. Inflorescentiae axillares, circa 3 cm. longae, ramosae, papillosae, bracteis ovatis, pedicello subnullo, sepalis ovatis 1.5 mm. longis extra papillosis dorso carinatis, corolla (tantum juvenili) sepalis aequilonga ad medium 5-loba, lobis ovatis, antheris sagittatis sessilibus tubo fere aequilongis, ovario conico lateraliter compresso medioque sulcato, stylo subulato aequilongo. Fructus (2.5 cm. x 2 cm.), maturitate rubri, drupis 2, epicarpio tenuissimo, endocarpium una facie convexa, altera applanata medioque sulcata.

A n e i t y u m: Anelgauhat Bay, common on sea shore at sea level, no. 925, March 17, 1929 (small tree up to 6 m. high; fruit 2.5 cm. long, 1.75 cm. in diam., red when ripe; sap milky).

Very remarkable on account of its flowers and leaves which quite resemble those of *A. bracteolosa* Rich. ex A. Gray var. *angustifolia* A. Gray from the Tonga Islands.

Ochrosia elliptica Labillardière, Sert. Austro-Caled. 25, t. 30 (1824).

A n e i t y u m: Anelgauhat Bay, common in rain-forest at sea level, no. 693, Feb. 4, 1929 (small tree up to 6 m. high, sap milky; leaves dark green; fruit red when ripe, 3.75 cm. long). *E r o m a n g a*: Dillon Bay, common in rain-forest close to sea beach, at sea level, no. 360, June 4, 1928 (large shrub up to 6 m. high; fruit red).—Also New Caledonia, Australia (Queensland), Fiji, Tonga and Society Islands.—Vernacular name "Naugh-comb" (under no. 360).

Ochrosia parviflora Henslow in Ann. Nat. Hist. i. 345 (1838).

Ochrosia elliptica K. Schumann, non Labillardière.

A n e i t y u m: Anelgauhat Bay, common on seashore at sea level, no. 947, March 19, 1929 (medium sized tree up to 9 m. high; flowers white; fruit 8 cm. long, 5.5 cm. in diam.). *E r o m a n g a*: Dillon Bay, common in rain-forest at sea level, no. 405, June 8, 1928 (large tree up to 15 m. high; flowers white; seed eaten by the natives). *E f a t e*: Undine Bay, common in rain-forest at sea level, no. 207, April 25, 1928 (tree up to 20 m. high; white sap flows freely from branches but not from the trunk).—Also Fiji, Solomon, Bismarck and Admiralty Islands, New Guinea, Aru Islands, Malaysia.—Vernacular name "Yefat" (under no. 405).

Alstonia villosa Seem. form. *calvescens* Markgraf in Bot. Jahrb. LXI. 198 (1927).

A n e i t y u m: Anelgauhat Bay, common in rain-forest at 60 m., no. 740, Feb. 12, 1929 (small tree up to 9 m. high; flowers white).

Eromanga: Dillon Bay, common in rain-forest and red soil, bracken country, no. 292, May 23, 1928 (small tree up to 8 m. high; flowers white; fruit hangs down like a long appendage, 25 cm. long).—Also Bismarck and Key Islands, North Australia, Malaysia.—Vernacular name “Ne-ye-vi-are” (under no. 292).

Ervatamia orientalis (R. Br.) Turrill in Jour. Linn. Soc. XLIII. 32 (1915).

Tabernaemontana orientalis R. Brown Fl. Nov. Holl. Prodr. 468 (1810).

Aneityum: Anelgauhat Bay, common in rain-forest at sea level, no. 692, Feb. 4, 1929 (small tree up to 10 m. high, sap milky; leaves bright green; flowers white; fruit brownish red when ripe). **Tanna:** Lenakel, common in heavy rain-forest soil at 45 m., no. 13, Feb. 20, 1928 (small tree with numerous branches; leaves bright green; flowers white).—Already found on Aneityum, Tanna, Eromanga and Efate; also Loyalty Islands, Australia (North Australia, Queensland, New South Wales), Fiji, Tonga and Society Islands, New Guinea, Malaysia.

Parsonsia neo-ebudica Guillaumin, sp. nov.

Scandens, foliis oppositis rigide membranaceis vel sub-coriaceis ovatis (usque ad 12 cm. x 6 cm.) apice breviter acuteque acuminatis basi rotundatis glaberrimis, nervis immersis 8–9-jugis arcuatis, petiolo 2–3 cm. longo. Inflorescentiae axillares, 4–6 cm. longae, laxiflorae, 9–11-florae, pedunculo 3–4 cm. longo, ramis 0.5–1.5 cm. longis, bracteis minimis subulatis, pedicellis usque ad 5 mm. longis ut pedunculo glaberrimis, calycis lobis acute triangularibus, 1.5 mm. longis glaberrimis, corolla 8 mm. longa, lobis anguste lanceolatis tubo sub-2-plo longioribus infra supraque faucem dense deorsum barbata, staminum filamentis 2 mm. longis, antheris filamentis 2-plo longioribus basi longe sagittatim appendiculatis, disco 5-crenato ovario aequialto, ovario glabro, stylo gracili, stigmatibus cylindricis dilatato antherarum tertiam supremam partem attingente.

Eromanga: Dillon Bay, common in rain-forest at 300 m., no. 396, June 8, 1928 (vine growing over the tops of rain-forest trees; used by natives in binding trees).—Vernacular name “No-satamus.”

Seems to approach especially *P. spiralis* Wall. of New Guinea, of the Aru and Key Islands, the Philippines, Malaysia and Asia, but its flowers are much smaller, the sepals acute and the corolla pubescent inside part of its length.

ASCLEPIADACEAE

Asclepias curassavica Linnaeus, Sp. Pl. 215 (1753).—Willdenow, Sp. Pl. 1. 1266 (1798).

Aneityum: Anelgauhat Bay, common in open country at sea level, no. 930, March 17, 1929 (small weed up to 1 m. high; flowers orange and yellow; the natives say this is indigenous to the islands as they have a native name for it). *Eromanga*: Dillon Bay, common in open grassy country at 300 m., no. 388, June 8, 1928 (weed up to 1 m. high; flowers red; suspected poisonous weed).—Already found on Aneityum; also New Caledonia, Loyalty Islands, Australia (Queensland), Tonga, Samoa, Cook, Society, Marquesas, Marshall and Mariana Islands, Malaysia, Hawaii (introduced).—Vernacular name "Te-vess" (under no. 388).

Hoya australis R. Brown apud Traill in Trans. Hort. Soc. VII. 28 (1830).

Aneityum: Utgi, plentiful on seashore at 90 m., no. 1002, (coll. *J. P. Wilson*), Sept. 1929 (vine; leaves medium, light green, fleshy; flowers small, white; fruit long spike-like pods, 12.5 cm. long, 1.2 cm. in diam.).—Already found on Tanna and Efate; also Queensland, Fiji, Samoa, Solomon? and Bismarck?? Islands.—Vernacular name "Napalht."

The specimen cited differs from the description of R. Brown only in the petals being entirely papillose on their whole upper surface. The young parts (branchlets and the leaves on both sides) are copiously villous which corresponds with Seemann's remarks (Fl. Vit. p. 163) concerning his *H. pilosa*. It would be very desirable to make a complete revision of the specimens referred to this species. Schlechter (in Bot. Jahrb. L. 118) has already drawn attention to the confusion particularly in regard to the specimen of Naumann from the Solomon Islands which he considers as the type of a distinct species: *H. Naumannii* Schlechter, while Engler refers it to *H. australis* R. Br.

Tylophora aneityensis Guillaumin, sp. nov.

Scandens, ramis gracilibus flexuosis teretibus glaberrimis, foliis (in sicco) rigide membranaceis ovatis (usque ad 6 cm. x 4 cm.) apice attenuatis mucronatisque basi rotundatis et saepius glandulosis, petiolo 1.5–2 cm. longo. Inflorescentiae extra-axillares, 5–9 cm. longae, paniculatae, parte florifera 0.5 cm. longa racemosa, bracteis numerosis minimis ciliatis imbricatis, floribus subflavis numerosis, pedicello capillari, corolla fere aequilongo, calycis lobis ovatis obtusis 1.5 mm. longis margine sparse ciliolatis basi tantum coalitis, corollae lobis ima basi tantum coalitis lineari-ellipticis (8 mm. x 3 mm.) apice rotundatis 7-nervis, coronae squamis triangulari-ovatis 1 mm. altis obtusiusculis, carnosae antherarum basin superantibus, antheris parallelipedis basi acutis apice ap-

pendice hyalina semi-orbiculari, polliniis globosis, translatoribus brevibus, retinaculo ovoideo-elongato polliniis aequilongo, stigmatis capite plano stamina haud superante. Folliculus (tantum immaturus) globosa-compressus (2 cm. x 1.8 cm.), apice apiculatus, pedicello 6 mm. longo.

Aneityum: Anelgauhat Bay, common on sea shore at sea level, no. 796, Feb. 21, 1929 (vine growing over undergrowth on sea shore; petals cream-colored).

The most closely related species seems to be *T. Brackenridgei* A. Gray from the Fiji Islands. The genus was already known from the Torres Islands by a specimen not specifically determined.

Tylophora tannaensis Guillaumin, sp. nov.

Scandens, ramis gracilibus flexuosis teretibus glaberrimis, foliis (in sicco) membranaceis ovatis (usque ad 6.5 cm. x 4 cm.) apice mucronatis rotundatis vel etiam emarginatulis basi rotundatis glandulosisque, petiolo circa 2 cm. longo. Inflorescentiae extra-axillares, usque ad 8 cm. longae, umbellatae, rarius paniculatim umbellatae, pedunculo communi 1.5–2.5 cm. longo, glabro, bracteis minimis extra puberulis floribus albis numerosis, pedicello capillari corolla 2-plo longiore vel ultra sparsissimeque puberulo deinde glabrescente, calycis lobis late ovatis apice rotundatis 2 mm. longis dorso sparse puberulis basi tantum coalitis, corollae lobis ima basi tantum coalitis lineari-ellipticis (1 cm. x 3.5 mm.) apice rotundatis 7-nervis, coronae squamis ovato-acutis, 1.5 mm. altis acutis carnosis, ad antherarum medium attingentibus, antheris parallelipedis basi obtusis apice appendice hyalina semi-orbiculari, polliniis globosis, translatoribus brevibus, retinaculo ovoideo-elongato, stigmatis capite plano stigma non superante.

Tanna: Lenakel, common in rain-forest at sea level, no. 20, Feb. 21, 1928 (vine climbing up on rain-forest trees; flowers white).

Extremely close to the preceding species, but different in its inflorescence, the much longer pedicels and the presence of soft scattered hairs on the pedicels and the back of the sepals and in the acute apex of the scales of the corolla.

LOGANIACEAE

Geniostoma rupestris Forster, Char. Gen. 24, t. 12 (1776).

Aneityum: Anelgauhat Bay, common in rain-forest at 30 m., no. 728, Feb. 11, 1929 (small tree up to 9 m. high; leaves dull, dark green; petals white).—Already found on Tanna; also Fiji, Tonga, Samoa, Cook and Society Islands.

Fagraea sp.

Aneityum: Anelgauhat Bay, common in rain-forest at 100 m.,

no. 734, Feb. 11, 1929 (large tree up to 18 m. high; leaves dark green, flowers yellow).

Couthovia neo-ebudica Guillaumin, sp. nov.

Arbor parva, 12 m. alta, foliis ovatis (13–20 cm. x 6–10 cm.) basi cuneatis apice rotundato-obtusis vel latissime acuminatis, sat crassis, petiolo pro genere gracili 1.5–3 cm. longo, nervis 5–6-jugis, venis immersis, stipulis interpetiolaribus majusculis coriaceis brevissime obtusis, cum petiolis in cupulam usque ad 1 cm. altam coalitis nunquam fissis. Inflorescentia composite cymosa, pedunculo robusto 1.5 cm. longo, ramis I. ord. 7–7.5 cm. longis brevissime sparsissimeque tomentellis, II. ord. 2–3 cm. longis et III. ord. 3–8 mm. longis densius longiusque tomentellis, pedicellis nullis vel brevissimis et dense tomentellis, bracteis minimis suborbicularibus margine dense ciliatis 1 mm. longis corolla . . . , staminibus . . . , ovario ovoideo-elongato in stylum indistincte attenuato, stigmate capitato. Fructus elongati (fere 4 cm. x 1 cm.), inferne in stipitem curvatum attenuatis, apice sensim longe acuteque attenuati.

A n e i t y u m: Anelgauhat Bay, common in rain-forest up to 180 m., no. 774, Feb. 18, 1929 (small tree up to 12 m. high; flowers sweetly scented; fruit when gathered 4 cm. long, 1 cm. in diam.).

To be placed near *C. densiflora* K. Schum. and *C. terminalioides* Gilg & Bened. from New Guinea.

BORAGINACEAE

Cordia Myxa Linnaeus, Sp. Pl. 190 (1753).

A n e i t y u m: Anelgauhat Bay, common in rain-forest at sea level, no. 691, Feb. 4, 1928 (small tree up to 15 m. high; fruit pinkish brown when ripe, 4 cm. long, 3 cm. in diameter). **E r o m a n g a**: Dillon Bay, rain-forest, 300 m., common, no. 397, June 8, 1928 (fruit red when ripe; bark used for grass skirts and berries to feed pigs). **T a n n a**: Lenakel, common in rain-forest at 100 m., no. 42, Feb. 22, 1928 (tree 7 to 10 m. high; fruit pink when ripe).—Already found on Tanna; also New Caledonia, Australia, (Queensland), Society and Marquesas Islands, New Guinea, Malaysia.—Vernacular name “Yalehoi” (under no. 397).

Tournefortia argentea Linnaeus f., Suppl. 133 (1781).

A n e i t y u m: Anelgauhat Bay, common on sea shore at sea level, no. 795, Feb. 20, 1929 (small tree up to 9 m. high; flowers white). **T a n n a**: Lenakel, common on sea shore at sea level, no. 78, March 3, 1928 (tree about 10 m. high with very spreading top). **E r o m a n g a**: Dillon Bay, common along sea coast at sea level, no. 406, June 8, 1928 (small, well-branched tree up to 10 m. high, only

along sea shore). **Banks Group:** Vanua Lava, common on sea shore at sea level, no. 425, July 6, 1928 (small tree up to 8 m. high; common on all the shores of the New Hebrides).—Already found on Efate; also New Caledonia, Loyalty Islands, Australia (Queensland, North Australia), Fiji, Tonga, Samoa, Cook, Society, Paumotu, Union, Ellice, Gilbert, Marshall, Caroline, Mariana, Solomon, Bismarck and Admiralty Islands, New Guinea, Malaysia, Hawaii.—Vernacular name “Ney-in-pori” (under no. 406).

CONVOLVULACEAE

***Ipomoea congesta* R. Brown, Fl. Nov. Holl. Prod. 485 (1810).**

Banks Group: Vanua Lava, common in rain-forest at sea level, no. 449, July 9, 1928 (climber; flower very pretty, puce-colored with a white base; grows freely both in scrub and plantations).—Already found on Tanna and on Efate; also New Caledonia, Australia (Queensland), Norfolk, Fiji, Tonga and Mariana Islands, New Guinea, Hawaii.

? ***Ipomoea denticulata* Choisy in Mém. Soc. Phys. Genève, vi. 447 (1833).**

Eromanga: Dillon Bay, common in open grass country at 300 m., no. 320, May 28, 1928 (vine growing over small bushes; flowers white).—Already found on Aneityum and Efate; also Australia (Queensland), Tonga, Fiji, Society, Marshall, Solomon and Bismarck Islands, New Guinea, Malaysia.—Vernacular name “Niye-eni-usak-wavi.”

***Ipomoea pes-caprae* Roth, Nov. Pl. Sp. 109 (1821).**

Aneityum: Anelgauhat Bay, common on sea shore at sea level, no. 815, Feb. 26, 1929 (creeping vine growing on the sand close to the sea beaches; flowers purple; found throughout the entire group). **Eromanga:** Dillon Bay, common on sea beach at sea level, no. 332, May 29, 1928 (vine growing close to the sea and in some plantations adjoining the sea it is a pest; flowers purple).—Also New Caledonia, Australia (Queensland, New South Wales, North Australia, West Australia), New Zealand, Fiji, Tonga, Samoa, Cook, Marquesas, Ellice, Marshall, Mariana, Solomon, Bismarck and Admiralty Islands, Malaysia, Hawaii.—Vernacular name “Novi-wavu” (under no. 332).

***Ipomoea turpethum* R. Brown, Fl. Nov. Holl. Prod. 485 (1810).**

Banks Group: Vanua Lava, common in rain-forest at sea level, no. 450, July 9, 1928 (common in the New Hebrides; flower large, snow white).—Already found on Aneityum, Tanna and Eromanga; also New Caledonia, Loyalty Islands, Australia (Queensland), Fiji, Tonga, Samoa, Society and Bismarck Islands, Malaysia.

SOLANACEAE

Datura arborea Linnaeus, Sp. Pl. 179 (1753).

Tanna: Ikiti, common in rain-forest at 100 m., no. 175, March 16, 1928 (shrub up to 4 m. high; flowers cream).

A South American species already introduced to Australia (West Australia) and to Tahiti.

GESNERIACEAE

Cyrtandra aneiteensis C. B. Clarke in De Candolle, Monog. Phan. v. 282 (1883).

Descriptioni adde: Corolla sub-flava extra ad tubi apicem lobisque villosula, ceterum glabra, tubo cylindrico 12 mm. longo, lobis 5 rotundatis, 3 posterioribus 4 mm. longis, 2 anterioribus 3 mm. longis, staminibus 2 ad apicem tubi insertis, filamentis antheribusque aequilongis annulum horizontalem formantibus, antheris albis apice coherentibus.

Aneityum: Anelgauhat Bay, common in rain-forest at 180 m., no. 773, Feb. 18, 1929 (plant up to 1.80 m. high, growing in rain-forest clearings; petals creamy green).—Already found on Aneityum.

Except that the calyx is still persistent on the young fruit, all the other characters agree with the description by Clarke. The hitherto unknown corolla is described above.

Cyrtandra cymosa J. & G. Forster, Char. Gen. 6 (1776).

Banks Group: Vanua Lava, common in rain-forest at 200 m., no. 452, July 10, 1928 (small tree up to 3 m. high; flowers creamy yellow).—Already found on Aneityum and Tanna.

The specimen differs from the type in the much longer petioles (up to 7 cm. long) scarcely undulate on the margin.

Cyrtandra Kajewskii Guillaumin, sp. nov.

Frutex 2 m. alta, ramis novellis dense rufo-hirsutis, deinde glabris, foliis⁶ oppositis aequalibus elongato-ellipticis (usque ad 30 cm. x 11 cm.) basi longe attenuatis apice obtusis margine serratis membranaeis, novellis dense rufo-hirsutis deinde margine et costa subtus exceptis glaberrimis, nervis circa 12-jugis, petiolo 2–3 cm. longo, rufo-hirsuto. Inflorescentiae petiolo aequilongae, pedunculo sub-nullo, bracteis lanceolatis (1 cm. x 0.4 cm.) margine pilosis, pagina inferiore hirsutis, pedicellis fasciculatis 1 cm. longis sparse hirsutis, calyce 7 mm. alto ad tertiam partem fisso intus extraque glaberrimo, lobis 5 lanceolatis acuminatis, corolla extra ad tubi apicem lobisque sparse villosa, ceterum glabra, tubo 2 cm. longo apicem versus dilatato, lobis rotundatis, 5 mm. longis, staminibus 2, ad tubi apicem insertis, filamentis brevissimis horizontaliter

annularibus, antheris . . . , ovario glaberrimo in stylum attenuato 1.5 cm. longo, apice sparsissime hirsuto, stigmatibus discoideo peltato, disco tubuloso 2 mm. alto apice 5-undulato. Fructus, tantum novelli, fusiformes, basi calyce cincti.

Tanna: Lenakel, common in rain-forest soil at 200 m., no. 62, Feb. 24, 1928 (shrub about 2 m. high, found on banks of gullies).

This species is similar to *C. aneiteensis* C. B. Clarke but is clearly distinct by its much larger flowers with a tube enlarged above and by the perfectly glabrous calyx.

ACANTHACEAE

Hemigraphis reptans T. Anderson apud Hemsley, Rep. Sci. Res. Voy. Challenger, Bot. i. pt. III, 173 (1885).

Aneityum: Anelgauhat Bay, common in rain-forest at 240 m., no. 903, March 11, 1929 (small plant up to 80 or 100 cm. high; flowers pink).—Already found on Aneityum, Tanna, Efate, Eromanga and Espiritu Santo; also New Caledonia, Loyalty, Tonga, Marshall, Solomon, Bismarck and Admiralty Islands, New Guinea, Malaysia.

Acanthus ilicifolius Linnaeus, Sp. Pl. 639 (1753).

Efate: Undine Bay, common at sea level in rain-forest on salt water creek, no. 195, April 24, 1928 (growing in large clumps or patches, the canes of which have a sprawling habit; flowers puce-colored; fruit brown when ripe).—Already found on Tanna; also New Caledonia, Australia (Queensland, North Australia), Bismarck Islands, New Guinea, Malaysia.

Pseuderanthemum laxiflorum (Gray) Hubbard in Rhodora, XVIII. 159 (1916).

Tanna: Lenakel, common in native gardens, rain-forest at 150 m., no. 83, March 3, 1928 (shrub about 4 m. high; flowers white with violet centers).—Already found on Eromanga (ined.); also Fiji Islands.

Pseuderanthemum sp.

Banks Group: Vanua Lava, common in rain-forest at 300 m., no. 457, July 12, 1928 (plant up to 75 cm. high; petals white with pale pink bases).

VERBENACEAE

Stachytarpheta indica Vahl, Enum. i. 206 (1805).

Tanna: Lenakel, common in rain-forest soil at 100 m., on all levels, no. 40, Feb. 22, 1928 (common weed 1–1.5 m. high; flowers bright blue).—Also found on New Caledonia, Loyalty, Samoa, Caroline Islands, Malaysia.

Vitex Negundo Linnaeus, Sp. Pl. 638 (1753).

Aneityum: Anelgauhat Bay, common on seashore at sea level, no. 801, Feb. 21, 1929 (shrub up to 3 m. high, growing on the beach; leaves silvery underneath; flowers blue; fruit yellow when ripe).—Also New Caledonia, Mariana Islands, Malaysia.

Vitex rapinioides Guillaumin, sp. nov.

Arbor usque ad 20 m. alta, trunco 60 cm. diam., ligno luteo, ramis luteis primum puberulis, foliis usque ad 15 cm. longis, 3–5 foliolatis, foliolis ovatis (9 cm. x 5 cm., 7 cm. x 4 cm., 3 cm. x 1.5 cm.) basi obtusis vel cuneatis apice acuminatis rigide membranaceis, nervis 5–9-jugis, petiolulis 1 cm., 0.5 cm., 0.25 cm. longis, petiolo 2.5–5 cm. longo, primum lamina, petiolis, petiolulo rufo-puberulis, deinde lamina glabra infra glanduloso-punctata, petiolulis et petiolo glabrescentibus. Inflorescentia cymosa, ad 4 cm. longa, 3-flora, pedunculo gracili 1–1.5 cm. longo sparse rufo-puberulo, apice bracteis 2 filiformibus 2–3 mm. longis rufo-puberulis munito, pedicellis 1.5–2 cm. longis, lateralibus medio bracteolis 2 oppositis rufo-glanduloso-puberulis 1 mm. longis munitis, floribus roseis, calyce campanulato integro 4 mm. alto extra dense rufo-glanduloso margine rufo-lanuginoso 4-penicellato, corolla circa 2 cm. longa extra basi excepta dense rufo-puberula, tubo circa 1.5 cm. longo intus supra staminum insertionem lanuginoso, lobis rotundatis, majore 6 mm. longo, intus lanuginosis, staminibus exsertis, filamentis 3 mm. supra basin insertis lanuginosis, ovario globoso glabro 4-loculari, stylo elongato, apice 2-fido. Fructus rubri, depresso globosi (1.3 cm. x 1.5 cm.), calyce patellato 6 mm. diam., putamine circa 5 mm. crasso 4-loculari.

Aneityum: Aname, west coast, common on seashore to 15 m., no. 992 (coll. *J. P. Wilson*) (type), Sept. 1929 (large tree to 60 cm. in diam.; leaves medium; flowers small, pink, bell-shaped; fruit red 1.2 cm. long, 1–5 cm. in diam.). *Eromanga*: Dillon Bay, common in rain-forest at 300 m., no. 299, May 24, 1928 (large tree up to 20 m. high; fruit red; common in the southern group; wood very hard and used by the natives in house building). *Efate*: Undine Bay, common in rain-forest at 100 m., no. 211, April 26, 1928 (tree with yellow wood and very faulty, up to 20 m. high; flowers pink; fruit pink). Vernacular names “Inedic” (under no. 992) and “Nay-mofsi” (under no. 299).

Nearest to *V. Rapini* Beauv. of New Caledonia which has the leaves much thinner and of different shape. The specimen from Efate is remarkable for its more elongated oval-lanceolate or lanceolate leaves.

Vitex trifolia Linnaeus, Sp. Pl. 638 (1753).

Aneityum: Anelgauhat Bay, common on the sea shore at sea level, no. 690, Feb. 4, 1929 (small plant up to 25 cm. high growing on sand beach; leaves silver-green; flowers light blue). **Tanna:** Lenakel, not common, in rain-forest soil at 200 m., no. 66, Feb. 24, 1928 (small tree about 4 m. high); common in native gardens of rain-forest soil at 150 m., no. 84, March 3, 1928 (shrub about 4 m. high; leaves variegated with white; flowers blue).—Already found on Aneityum, Tanna, and Epi; also New Caledonia, Australia (Queensland, North Australia), Norfolk, Fiji, Tonga, Samoa, Cook, Marquesas, Caroline, Mariana and Bismarck Islands, New Guinea, Malaysia, Hawaii.

Faradaya neo-ebudica Guillaumin, sp. nov.

Alte scandens, cortice fulvo, foliis oppositis late vel latissime ovatis (usque ad 14 cm. x 11 cm.) apice brevissime subitque acuminatis vel subrotundatis basi cuneatis, leviter coriaceis, nervis 4-6-jugis, venis reticulatis ut nervis subtus tantum prominulis, petiolo 1-4 cm. longo. Inflorescentiae axillares, 5-7 cm. longae, centrifuge corymboso-dichotome cymosae, sparse puberulae, bracteis lanceolatis (1 cm. x 0.3 cm.) basin versus longe attenuatis in utraque pagina rufo-puberulis, floribus albis, centrali pedicello rufo puberulo 1 cm. longo suffulto, calyce primum clauso sparse puberulo deinde in lobos 4 valvatim fissus tunc 8 mm. longo, corollae lobis 1 exteriore majore, 1 intermedio leviter minore, ut exteriore margine integerrimo, 2 interioribus minoribus margineque suberosis, tubo 3-plo brevioribus, staminibus 4 medio tubi insertis leviter exsertis, antheris in alabastro inflexis ellipticis, loculis parallelis, ovario breviter 4-lobo 4-loculari, loculis 1-ovulatis, ovulis alte insertis, stylo staminibus breviori, stigmate 2-lamellato.

Aneityum: Anelgauhat Bay, common in rain-forest at 120 m., no. 813, Feb. 29, 1929 (vine growing to the tops of rain-forest trees; flowers white).

I believe that on account of the calyx and the ovary, notwithstanding the fact that the scarcely exserted stamens are inserted at the middle and not at the mouth of the corolla-tube, this species should be referred to the genus *Faradaya* of New Guinea which extends to the Samoa Islands, Queensland and Borneo, but does not seem to occur in the Moluccas and in Malaysia.

Premna integrifolia Linnaeus, Mant. Alt. 252 (1771).

Efate: Undine Bay, common in rain-forest at sea level, no. 208, April 25, 1928 (spreading tree growing close to the beach). **Banks Group:** Vanua Lava, common in rain-forest at sea level, no. 439, July 9, 1928 (large tree up to 15 m. high, very common throughout

the New Hebrides; flowers cream).—Already found on Efate; Also New Caledonia, Loyalty, Marshall, Mariana, and Bismarck Islands, New Guinea, Malaysia.

Clerodendron inerme Gaertner, Fruct. i. 271 (1788).

E f a t e: Fila Island, Vila, common on seashore at sea level, no. 185, April 13, 1928 (shrub about 3 m. high; flowers white).—Also New Caledonia, Loyalty Islands, Australia (Queensland, New South Wales, North Australia), Fiji, Tonga, Samoa, Caroline, Mariana, Santa Cruz, Solomon, Bismarck and Admiralty Islands, New Guinea, Malaysia.

LABIATAE

Ocimum sanctum Linnaeus, Mant. 85 (1767).

T a n n a: Lenakel, common in native gardens of rain-forest, at 200 m., nos. 64 and 65, Feb. 24, 1928 (herb. about 33 cm. high).—Already found on Efate and Espiritu Santo; also Australia (North Australia), Solomon, Bismarck and Mariana Islands, New Guinea, Malaysia.

Coleus scutellarioides Benthham in Wallich, Pl. As. Rar. ii. 16 (1831).

E r o m a n g a: Dillon Bay, common in poor red soil, bracken country, at 400 m., no. 316, May 28, 1928 (small plant up to 75 cm. high; flowers blue).—Already found on Tanna, Eromanga, Efate and Espiritu Santo; also New Caledonia, Australia (North Australia) Bismarck Islands, New Guinea, Malaysia.—Vernacular name "Ou-lair-ung."

Plectranthus Forsteri Benthham, Lab. Gen. et Sp. 38 (1832).

E r o m a n g a: Dillon Bay, common on sea shore at sea level, no. 258, May 15, 1928 (small plant about 50 cm. high; flowers pale blue; used by natives for sores, sap taken and mixed with salt water).—Already found on Aneityum, Tanna and Eromanga; also Isle of Pines, Fiji and Samoa Islands.

(To be continued)

MUSEUM NATIONAL D'HISTOIRE NATURELLE,
PARIS.

KALMIOPSIS, A NEW GENUS OF ERICACEAE FROM
NORTHWEST AMERICA

ALFRED REHDER

Plate 40

THE DISCOVERY in Oregon by Mr. and Mrs. Leach of a new ericaceous shrub subsequently described by L. F. Henderson as *Rhododendron Leachianum*¹ is highly interesting, particularly as this shrub turns out to be a new genus related to *Loiseleuria* and *Kalmia* and also to *Rhododendron* for which I propose the name *Kalmiopsis* referring to its general resemblance to *Kalmia polifolia* Wangeh. In its inflorescence it agrees closely with *Kalmia polifolia* Wangeh. except that it has alternate instead of opposite bracts. The inflorescence in both species is a short raceme terminating last year's branchlets; the bracts decrease in size toward the apex, the lowest being more or less leaf-like; the persistent bractlets surround the pedicels at the base and together with the bract act as protecting scales for the flower-buds during the winter. The calyx in both species is 5-parted, rather large, colored and gibbous at the base, forming a ring around the immersed apex of the slender pedicel. The corolla is similar in size and color in both species, but in *Kalmiopsis* more campanulate and lacking the peculiar pouches of *Kalmia*. The capsule is subglobose and thin-walled and the valves bifid at the apex in both genera. In *Kalmiopsis* the under side of the leaves and the inflorescence are dotted with lepidote glands absent in the genus *Kalmia*. *Loiseleuria* has the same inflorescence as *Kalmia polifolia* though reduced to fewer flowers, the calyx too, is similar, but the number of stamens is only 5, the anthers are dehiscent by longitudinal slits and the ovary is 2-3-celled. The capsule is similar to *Kalmia* and *Kalmiopsis*. Like *Kalmia* it lacks the glandular dots on the leaves and inflorescence. *Rhododendron* differs chiefly in its seeds which are enclosed in a loose and thin elongated testa lacerated or fringed at the ends and in the capsule which is more or less elongated, has woody walls and the valves not bifid at the apex. Its inflorescence, too, is very different, being an umbel-like raceme sometimes reduced to one flower, enclosed in scaly winter-buds before anthesis except in the subgenus *Therorhodon* which has a one- to two-flowered inflorescence terminating leafy shoots of the current year; it may well be considered a distinct genus as proposed by Small, connecting *Rhododendron* with *Rhodo-*

¹ L. F. Henderson in *Rhodora*, XXXIII. 205 (1931).

thamnus. The flowers in *Rhododendron* are more or less zygomorphous while in *Kalmiopsis* as in the two genera mentioned above they are actinomorphic. The peculiar lepidote glands are copiously present in the numerous species of the subgenus *Eurhododendron* Endl. except its section *Leiorhodion* Rehd. In its inflorescence and in the structure of its flowers *Kalmiopsis* shows a rather close relation also to *Phyllodoce* Salisb. and *Rhodothamnus* Reichenb. Both differ in the absence of lepidote glands on the under side of the leaves and on the inflorescence; *Phyllodoce* also in the crowded linear strongly reflexed leaves, the ovoid to campanulate corolla and the elongated style, and *Rhodothamnus* Reichenb. in the slightly zygmorphous flower, rotate corolla, long exserted style and long-ciliate leaves.

The new genus represents apparently, like *Loiseleuria* and *Rhodothamnus*, a phylogenetically old type of the Tertiary. The age of these three monotypic genera is also shown by the fact that they do not exhibit any variation, while *Rhododendron*, *Kalmia* and *Phyllodoce*, genera probably derived from these monotypic genera, have split up into many species, *Rhododendron* being apparently the youngest and most unstable in its specific characters. *Loiseleuria* being an arctic plant has still a wide circumpolar distribution, while *Rhodothamnus* is a relict of the European Alps and *Kalmiopsis* of the higher mountains of Northwest America. The last named is the most restricted, having been found so far only in two or three localities in the Siskiyou, a mountain range which shelters some other interesting local relicts as *Picea Breweriana* S. Wats., a species whose nearest relations are found now in southeastern Europe and Eastern Asia. Also *Quercus Sadleriana* R. Br. Campst. which is restricted to the same region has no close relation in western North America.

***Kalmiopsis*, gen. nov.**

Calyx 5-partitus, persistens, basi gibbosus, segmentis oblongo-ovatis; corolla late campanulata, 5-loba, lobis late ovatis obtusis; stamina 10, corollae subaequilonga, antheris dorsifixis poris apicalibus dehiscentibus, filamentis filiformibus basi leviter dilatatis et ciliolatis; discus tenuis, obscure 10-lobatus; stylus brevis rectus, stigmatibus capitato leviter lobulato; ovarium hemisphericum, 5-loculare, placentis angulo interiori medio adnatis bilobis multi-ovulatis; capsula subglobosa, crustacea, septicide 5-valva, valvis apice bifidis ab axi placentifero solutis; semina ovoidea, utrinque obtusa, testa firma leviter reticulata.—Frutex parvus, sempervirens, gemmis pauciperulatis, foliis coriaceis breviter petiolatis subtus glanduloso-lepidotis, margine minutissime spinuloso-ciliolatis, floribus in axillis

bractearum in apice ramulorum in racemum congestis, graciliter pedicellatis, pedicellis basi bracteolis persistentibus suffultis, fructu erecto.

Genus monotypicum, proximum *Loiseleuriae* Desv., *Kalmiae* L. et *Rhododendro* L. A primo praecipue differt staminibus 10, antheris poris apicalibus dehiscentibus, ovario 5-loculari, foliis alternis subtus glandulosa-lepidotis; a secundo staminibus ab initio liberis, non antheris in foveolis corollae inclusis, foliis subtus glandulosa-lepidotis; a tertio capsula subglobosa, parietibus tenuibus, valvis apice bifidis, seminibus ovoideis utrinque obtusis, testa firma. Magis distare videtur a *Phyllodoce* Salisb. quae foliis congestis linearibus valde revolutis et corolla ovoidea vel campanulata differt, et a *Rhodothamno* Reichenb. qui floribus leviter zygmorphis, corolla rotata, stylo exserto, foliis longe ciliatis et ut genus precedens defectu glandularum lepidotarum recedit.

Species unica Americae boreali-occidentalis incola.

Kalmiopsis Leachiana (Henderson), comb. nov.

Rhododendron Leachianum L. F. Henderson in *Rhodora*, XXXIII. 205 (1931).

Frutex erectus, valde ramosus, 15–25 cm. altus; ramuli annotini puberuli et sparse glandulosi; gemmae parvae, perulis paucis subfoliaceis ciliatis glanduloso-lepidotis. Folia sempervirentia, coriacea, elliptica, elliptico-oblonga vel elliptico-obovata, acuta vel obtusiuscula, rarius rotundata, mucronulata, basi cuneata, margine glabra vel fere glabra vel minutissime setoso-ciliolata, 1–2 cm. longa et 4–8 mm. lata, supra intense viridia, lucida et glabra vel interdum sparsissime glanduloso-lepidota, subtus paullo pallidiora et glandulis lucidis immersis distanter instructa, costa et venis 4–5 supra leviter impressis, subtus costa leviter prominula et venis vix visibilibus; petioli 1 mm. longi, minute puberuli et sparse glandulosi. Flores axillares, solitarii, 3–10 in apice ramulorum racemum umbellatim congestum formantes, flores inferiores in axillis foliorum parvorum apicum versus in bracteas ovato-lanceolatas glandulosas bracteolis paulo tantum longiores decrescentium; pedicelli graciles, 1–1.5 cm. longi, minute glanduloso-puberuli, imo basi bracteolis orbiculari-ovatis mucronulatis minute glanduloso-ciliolatis dorso glanduloso-lepidotis suffulti; calyx fere at basin partitus, lobis oblongo-ovatis vel ovatis 4–5 mm. longis obtusiusculis margine plus minusve glanduloso-ciliatis dorso sparsissime glanduloso-lepidotis vel glabris basi gibbosus et in annulum apicem pedicelli cingentem productus; corolla late campanulata, 10–12 mm. longa et 12–15 mm. lata, rosea, basin versus albescens, lobis late ovatis tubum latum circiter aequantibus margine leviter crenulatis vel undulatis

extus medio sparse glanduloso-lepidotis; stamina 10, corollam subaequantia, 8–10 mm. longa, filamentis glabris ima basi dilatata ciliata excepta, antheris oblongis 2 mm. longis lilacinis; pistillum dimidiam corollam aequans vel eam superans, stylo glabro 3.5 vel 8 mm. longo, stigmatē capitato, ovario depresso-globoso dense glanduloso-lepidoto basi disco nudo tenui leviter 10-crenato inclusa excepta. Capsula subglobosa, 4–5 mm. diam., calyce persistente suffulta, seminibus late ellipsoides utrinque obtusis 0.5 mm. longis fuscis minute granulatis.

Oregon: higher Siskiyou Mts., Curry County, *Mr. & Mrs. J. R. Leach*, no. 2915 (in part), June 14, 1930; rocky ground on Horse Sign Butte and along Collier Bar Trail, alt. 2000–4000 ft., Curry County, *Mr. & Mrs. J. R. Leach*, no. 2915 (in part), May and June 1931.—Type in the herbarium of the University of Oregon; isotypes in the herbarium of the Arnold Arboretum and in the Gray Herbarium.

The plants of the three collections show slight variations in several characters. The plants of the collection of 1930 from the higher Siskiyou Mountains have the leaves elliptic to elliptic-oblong, acute or acutish at the apex, and only slightly setulose or glabrous on the margin, the inflorescences are 3–7-flowered and the style is 3.5 mm. long. Of the two collections made in 1931 on Horse Sign Butte and along Collier Bar Trail, the one which bears fruits of the previous season has an inflorescence and leaves similar to the 1930 collection, but the latter are rather densely setulose-ciliate on the margin; the other collection has slightly shorter leaves elliptic to obovate-elliptic, obtuse or obtusish at the apex and with less densely ciliate margin, and has generally 2–3—sometimes to 5-flowered inflorescences and the style 8 mm. long, exceeding the corolla. The variations in the length of the style is interesting; it can hardly be explained as heterostyly which is unknown in Ericaceae and must apparently be considered a seminal variation. The question whether this character is concomitant with the shape of the leaves can possibly be solved by making collections with exact indications of the locality of flowering material from all the stations and at the same time paying attention to possible variations of individual plants. Also mature fruit is much needed since we have so far only old disintegrating fruit of the previous year.

It is highly desirable that this little Ericaceous shrub which is not only botanically very interesting, but is also with its attractive rosy-purple flowers a handsome ornamental shrub for the rock garden, should soon be introduced into cultivation, so that this genus may be preserved at least in cultivation if it should become

extinct in its native habitat, which, owing to its limited distribution, seems not impossible.

HERBARIUM, ARNOLD ARBORETUM
HARVARD UNIVERSITY.

EXPLANATION OF PLATE 40

- Fig. 1. Flowering branch from the 1930 collection (natural size).
Figs. 2 and 3. Flowers (magnified).
Fig. 4. Stamen (magnified).
Fig. 5. Longitudinal section of flower from the 1931 collection (magnified).
Fig. 6. Cross-section of ovary (magnified).
Fig. 7. Seed (magnified).
Fig. 8. Under surface of leaf from the 1930 collection (magnified).
Fig. 9. Leaf from flowering branch of the 1931 collection (natural size).



KALMIOPSIS LEACHIANA (Henders.) Rehd.

DIAXYLARY LATICIFEROUS CELLS OF BEAUMONTIA
GRANDIFLORA

R. H. WOODWORTH

Plate 41

AMONG the specimens taken for anatomical studies from the Harvard Botanical Gardens in Cienfuegos, Cuba, by Dr. R. H. Wetmore and the writer are stems of *Beaumontia grandiflora* Wall., an East Indian member of the Apocynaceae.

When the living stems are cut there is a copious exudation of latex. Stained transverse sections of the stem show a general distribution of latex cells in the phloem and an abundance of these elements in the outer region of the pith. Radial sections of the stem show these laticiferous members to be devoid of cross walls. Figure 2 pictures a meandering latex cell in the pith and figure 5 shows one in the phloem, surrounded by parenchyma. When tissue is differentiating below meristems some of these latex cells apparently work across the procambial region. As this region matures the cells adjacent to the latex cell are affected so that they remain parenchymatous (figures 1 and 4).

Often the latex cells do not pass from the pith to the xylem at right angles to the vascular elements but rather they swing in an arc for some distance finally settling in a horizontal position in the xylem (figures 1, 3, 4, 6, 11). Figures 1 and 3 picture the pith at the left, then several files of intraxylary phloem cells (sieve tubes with slime plugs), while the remaining tissue is xylem. Occasionally in the transverse section a latex cell is seen extending from the pith into the xylem entirely in the horizontal plane (figure 8, pith is in lower portion of the photograph). Figure 7 shows a similar situation where a latex cell extends from the xylem out into the phloem. As cambial activity increases the size of the stem the latex cell also apparently grows at the cambial region.

It has been mentioned above that parenchyma cells near the latex cell do not differentiate, in fact they make up what is essentially a ray. This is clearly shown in the tangential section through the xylem (figures 9 and 10). Figure 10 depicts the latex cell surrounded by parenchyma while figure 9 shows it in contact with wood fibers on one side. These two conditions appear in about equal proportions.

The fact that these horizontal latex cells accompanied by parenchyma connect with the vertical laticiferous system in the phloem

is brought out in figure 12, which is a tangential section through the phloem. Here the horizontally directed canal similar to those of figures 9 and 10 is seen to be in direct communication with a vertical laticiferous cell.

DEPARTMENT OF BOTANY,
HARVARD UNIVERSITY.



DIAXILARY LATICIFEROUS CELLS OF *BEAUMONTIA GRANDIFLORA*
(Explanation in the text)

CHROMOSOME NUMBERS AND THE ANATOMY OF THE
SECONDARY XYLEM IN THE OLEACEAE

KARL SAX AND ERNST C. ABBE

With two text figures

THE OLEACEAE form a natural family of plants, although there are well marked differences between most of the genera. The family is divided into the Oleoideae which includes *Fraxinus*, *Forsythia*, *Syringa*, *Forestiera*, *Chionanthus*, *Olea*, and *Ligustrum*, and the sub-family Jasminoideae which includes *Jasminum*. According to Rehder there are more than 20 genera with over 400 species, most of which are trees and shrubs.

The natural grouping of these genera is indicated not only by their taxonomic characters but also by their immunological, grafting, and anatomical relationships. Chester (1931) working with *Chionanthus*, *Fraxinus*, *Forsythia*, *Ligustrum* and *Syringa*, found no normal precipitin reactions between these genera.

According to DeCandolle the Lilac can be grafted on Ash, *Chionanthus* and *Fontanesia* while the Persian Lilac grafted on *Phillyrea* survived for ten years. The Olive can also be grafted on *Phillyrea* and *Fraxinus*. *Syringa* is commonly grafted on *Ligustrum* stock, although as Chester has pointed out, this practice often leads to "graft blight" due to incompatibility between stock and scion. The writer has seen *Syringa* grafts on *Fraxinus* which made a growth of several feet, but the graft does not survive the second year. These grafts were made by Dr. Johnson in Illinois. Chester found complete incompatibility of grafts between *Syringa* with *Chionanthus* and *Forsythia*. The fact that such morphologically diverse genera as *Syringa* and *Fraxinus* will function together, even for one season, indicates a rather close relationship between these genera.

The Oleaceae are widely distributed and are found in Asia, Europe, and America. Certain genera such as *Fraxinus* and *Chionanthus* are represented in both North America and Asia, while others such as *Syringa*, *Forsythia* and *Ligustrum* are natives of Asia and Europe. One genus, *Forestiera*, is found only in North and South America. The geographic distribution indicates that the family originated in Asia.

The relationships of the genera of Oleaceae would indicate that the chromosome complexes might be similar. Little cytological work has been done on this family. The writer (Sax, 1930) found 23-34 pairs of chromosomes in representative species of *Syringa*,

and Tischler (1930) reports 22 chromosomes for this genus. O'Mara (1930) found 14 pairs of chromosomes in *Forsythia*. The chromosome numbers of other genera available in the Arnold Arboretum have been investigated. The meiotic counts are based on aceto-carmine smear preparations. The writer is indebted to Mr. Dermen for the preparations of *Ligustrum*, *Olea* and *Jasminum*. Most of the chromosome counts for *Syringa* are based on the writer's earlier study of this group. The haploid chromosome numbers of the species studied are presented in the following table. The counts for *Olea* and *Jasminum* are based on preparations of root tips obtained from plants in the greenhouse.

Oleaceae

Genus	Species	Chromosome No.	Habitat
Fraxinus	Sec. 1. Bungeana	23	China
	chinensis	69	Asia
	Sec. 2. americana	23	N. America
	pennsylvanica	23	N. America
	oregona	23	N. America
	excelsior	23	Eu., Asia Minor
Forsythia	suspensa	14	China
	viridissima	14	China
	europaea	14	S. E. Europe
	ovata	14	Korea
Syringa			
Subgen. 1.			
Ser. 1.	yunnanensis	24-68	China
	Josikaea	23	S. E. Europe
	Sweginzowii	23	China
	villosa	23-24	China
	tomentella	23-24	China
	Komarowi	23	China
Syringa			
Ser. 2.	velutina	23	Asia
	Palibiniana	24	Korea
	pubescens	24	China
	Meyeri	23	China
	oblata Giralddii	23-24	China
	vulgaris (varieties)	23-24	S. E. Europe
	persica laciniata	22	China
	pinnatifolia	24	China
Subgen. 2.			
	amurensis	23	China
	japonica	23	Japan
Forestiera			
	acuminata	23	N. America
Chionanthus			
	virginica	23	N. America
Ligustrum			
	vulgare	23	Eu., N. Afr.
	Quihoui	23	China
	acuminatum	23	Japan

Genus	Species	Chromosome No.	Habitat
	<i>ibota</i>	23	Japan
	<i>acutissimum</i>	23	China
	<i>amurense</i>	23	China
	<i>obtusifolium</i>	23	Japan
<i>Olea</i>			
	<i>europaea</i>	23	S. Europe
<i>Jasminum</i>			
	<i>fruticans</i>	13	Mediterr. Reg.

The basic haploid chromosome number in *Fraxinus* is 23. One of the bivalent chromosomes seems to be conspicuously larger than the others, a situation also found in several other genera of this family. *Fraxinus chinensis* is a hexaploid with about 69 pairs of chromosomes. As shown in figure 2 there is no great amount of secondary pairing of the meiotic chromosomes.

All of the species, varieties and species hybrids of *Forsythia* have 14 pairs of chromosomes (O'Mara). The somatic chromosomes of *F. intermedia* are shown in figure 11. The size and shape of the somatic chromosomes are essentially the same as those of *Syringa* (Sax 1930), *Fraxinus* and *Olea*.

The chromosome number in *Syringa* seems to vary somewhat. Tischler (1930) reports 22 meiotic chromosomes in several species. The writer has found 22 pairs of chromosomes in *S. persica laciniata* (a fertile form from China), but 23 is the number most frequently found in the other species.

In the species hybrid *S. chinensis* (*S. persica* \times *S. vulgaris*) there are usually about 24 chromosomes at meiosis but in some cases the number at metaphase may be 36 (fig. 6) or more. In some division figures there seems to be about 12 bivalents and 12 univalents (Sax 1930) which would indicate that one of the parents contributed only 12 chromosomes in this cross. But both *S. vulgaris* and the fertile forms of *S. persica laciniata* have about 23 pairs of chromosomes.

Syringa persica and some of its varieties are also species hybrids as shown by the writer and by Tischler. The chromosome behavior is irregular and the plants are highly sterile. In some cases as many as 44 chromosomes have been counted at meiosis. It is probable that there is weak pairing of the chromosomes in these hybrids so that only univalent chromosomes are sometimes found at meiosis.

The haploid chromosome number is 23 for *Forestiera*, *Chionanthus* and *Ligustrum* (figs. 7, 8 and 9). There are 46 somatic chromosomes in *Olea europaea* which are similar to those of *Syringa* and *Forsythia* in respect to size and shape.

Jasminum has been placed in the subfamily Jasminoideae. The one species studied, *J. fruticans*, has 26 somatic chromosomes. As



TEXT FIGURE 1. CHROMOSOME NUMBERS IN OLEACEAE
(For explanation see p. 47)

shown in Figure 10, the somatic chromosomes are somewhat longer than those of the genera in the first group. The chromosome number and morphology in this genus seems to support the taxonomic grouping of this genus in a second subfamily.

Of the 8 genera studied 6 have 23 chromosomes as the basic number. It is possible that the original basic number was about 12, since *Forsythia* has 14 pairs of chromosomes and *Jasminum* has 13. There is also some evidence that in the species hybrid *S. chinensis* there may be approximately 12 bivalent and 12 univalent chromosomes at meiosis.

In general the genera and species of Oleaceae seem to constitute rather distinct genetic units. The only generic hybrid known is between *Osmanthus* and *Phillyrea* which was mentioned in a recent issue of Gardener's Chronicle (ser. 3, XC. 367. 1931). A few species hybrids are found in *Forsythia*, *Syringa* and *Ligustrum*. Numerous attempts have been made to cross species from different groups of the genus *Syringa* but without success.

The Oleaceae have been differentiated into rather well marked genera and species and have attained a wide geographic distribution with little change in chromosome number or chromosome morphology.

ANATOMY OF THE SECONDARY XYLEM

Before discussing the groups into which the genera under consideration naturally fall, it might be well to give a short description of each genus. The genera¹ studied are described in the order in which they are represented in Figure 2, (p. 46) reading up.

The material of *Jasminum*² available being only one year old, the conclusions based on it later are presented as being only tentative. The rays are uniformly uniseriate, and are composed of vertically elongate cells. Kohl (1881 p. 6) states that in more mature material they are rarely biseriate, and generally composed of vertically elongate or isodiametric cells (*J. revolutum*) only. The segments of the thin-walled, angular vessels have acute and porous end walls and gradually decrease in diameter in the course of the season's growth, so that a simple type of ring-porosity obtains. Parenchyma is both terminal and associated with the vessels. The tracheid walls are of medium thickness with rather large bordered pits whose orifices are not as long as the diameter of the pit membrane. Tertiary spiral thickening of the walls is present in both vessels and tracheids.

Forsythia,³ as well as the remaining genera, commonly has both

¹ The junior author had access to Professor I. W. Bailey's collection of slides, augmented by material kindly supplied by Alfred Rehder and Professor Record.

² Represented by *J. heterophyllum* Roxb. and *J. Giraldii* Diels.

³ Represented by *F. suspensa* Vahl, and *F. viridissima* Lindl.

multiseriate and uniseriate rays. The multiseriates in this genus are commonly two cells wide, and have uniseriate extensions which are longer than those in the other genera studied. The marginal cells are tall, although often also isodiametric in the radial plane. In arrangement the vessels are diffuse or weakly ring-porous and are mostly solitary, less often in radial groups of two or three, rarely in larger radial groups. In structure the vessel segments are thin-walled, angular, elongate, with acute end walls which are occasionally scalariform or tend to retain vestiges of bars when porous. The parenchyma occurs as isolated cells between the vessels, directly associated with the vessels, and also terminal. The tracheid walls are of medium thickness and have large bordered pits with short diagonal orifices. Both vessels and tracheids have spiral tertiary thickening.

The uniseriate rays in *Syringa*¹ are generally accompanied by biseriate rays although triseriates occur commonly in *S. Julianae* and *S. yunnanensis*. Uniseriate extensions may occur in the *Vulgares* group but are practically absent in the other two groups. The marginals are usually isodiametric in the radial plane, with a tendency towards their being vertically elongate in the species which have the longer uniseriate extensions. In the *Ligustrinae*, on the other hand, horizontally elongate marginals are more common. The vessel segments are elongate, thin-walled, angular with acute to obtuse end walls which are generally porous, although Solereder (1885, p. 171) reports having found scalariform end walls with a single bar in *S. vulgaris*.

Although the bulk of the species are ring-porous and have spiral thickenings in the tracheids and vessels, the members of the *Ligustrinae* have diffuse vessel arrangement, only very weak spiral thickening, and, in addition, have tyloses in the vessels.

The walls of the spring tracheids range from rather thin to medium thick, while in the summer wood they are medium thick to thick. The pits are bordered and have elongate, diagonal orifices which are as long or somewhat longer than the diameter of the pit membrane.

Both uniseriate and biseriate or triseriate rays are present in *Ligustrum*,² but uniseriate extensions are seldom present and are very short when they do occur. The marginal cells vary from isodiametric to vertically elongate. The angular, thin-walled vessels

¹ Represented in subgen. *Eusyringa* group *Villosae* by *S. yunnanensis* Franch., *S. villosa* Vahl; in *Eusyringa* group *Vulgares* by *S. Julianae* Schneid., *S. microphylla* Diels, *S. persica* L., *S. pinnatifolia* Hemsl., *S. pubescens* Turcz., *S. velutina* Komar.; in subgen. *Ligustrina* by *S. amurensis* Rupr., *S. japonica* Decne., *S. pekinensis* Rupr.

² Represented by *L. kiyozumianum* Nakai, *L. sinense* Lour., *L. vulgare* L.

have elongate segments with acute to obtuse, porous end walls. They are ring-porous in arrangement, most commonly occurring alone or in radial groups of two or three, or in long radial or diagonal rows (*L. sinense*).

The parenchyma is sparse and is only terminal or next to vessels.

The tracheids are medium to thick-walled and have bordered pits with orifices about as long or longer than the diameter of the pit membrane.

Associated with the uniseriate rays in *Chionanthus*¹ are bi-, tri-, and rarely 4- or 5-seriate rays which ordinarily completely lack uniseriate extensions, but may have short ones. The marginals are isodiametric or even horizontally elongate in the radial plane. The vessel segments are elongate, thin-walled, angular, and have acute end walls which are porous. The vessels occur in diagonal groups, forming "flames," the component vessels decreasing in size in the course of the year's growth. The wood parenchyma is terminal and also associated with the vessels. Tracheids are not very thick-walled and have bordered pits with elongate diagonal orifices about the width of the pit membrane.

The ray condition in *Fraxinus*² is quite variable but is predominantly fusiform associated with occasional uniseriates. The multi-seriates in some cases (*F. Sieboldiana*, *F. Biltmoreana*, *F. caroliniana*, *F. oregona*, *F. mandschurica*) may have an occasional very short uniseriate extension. The multiseriate rays generally far outbalance the uniseriates in number but *F. caroliniana* is a notable exception in this respect. The marginal cells are ordinarily horizontally elongate with a strong tendency especially in the *Melioides* toward the isodiametric type.

The vessel segments are of two types, the thick-walled, elongate ones of small diameter with obtuse to acute porous end walls, and the thin-walled, depressed segments with transverse porous end walls, relatively great diameter (4 or 5 × that of the later summer wood vessels). Both types occur singly or in radial pairs or groups of 3 or 4. The thick-walled vessels characterize the summer wood, and the thin-walled ones the spring wood. There is ordinarily a very rapid transition from the spring to the summer type of vessel resulting in a very definite ring-porous condition.

The parenchyma occurs both with the vessels and terminally,

¹ Represented by *C. virginica* L.

² Represented in § Ornus by *F. pubinervis* Bge., *F. chinensis* Roxb. var. *rhynchophylla* Hemsl., *F. floribunda* Wall., *F. Sieboldiana* Blume; in § *Fraxinaster* by *F. americana* L., *F. Biltmoreana* Beadle, *F. oregona* Nutt., *F. caroliniana* Mill., *F. pennsylvanica* Marsh.; in § *Melioides* by *F. mandschurica* Rupr., *F. quadrangulata* Michx., *F. nigra* Marsh.

with a strong tendency toward the formation of tangential bands in the summer wood.

The tracheids are thin-walled in the spring wood and thicker in the summer wood, having in both cases bordered pits with orifices as long as or longer (much longer in the summer wood) than the diameter of the pit membrane.

Tyloses generally fill the lumens of the vessels.

*Forestiera*¹ has both uniseriate and biseriate rays, the biseriate rays sometimes often lacking uniseriate extensions which do not average as long as in *Forsythia*. The marginal cells are much more rarely vertically elongate than in *Forsythia*, tending more commonly to be isodiametric in the radial plane of section. The vessels are diffuse in arrangement, occurring singly, or in pairs, less commonly in radial groups of three or rarely four. The rather thick-walled vessel segments are elongate with obtuse, porous end walls. Parenchyma is terminal and also associated with the vessels with a tendency toward tangential groups in *F. rhamnifolia* and well developed tangential rows in *F. porulosa*. The pitting of the rather thick-walled tracheids is typically bordered with the mouth of the pit varying in size from slightly less than to several times the diameter of the pit membrane.

In *Olea*² the multiseriate rays vary from bi- to triseriate, and are always associated with small uniseriates. Except in *O. europaea* which often has fairly long uniseriate extensions on the rays, they are fusiform. The marginal cells range from slightly elongate vertically to isodiametric in *O. europaea*, but in the other species they are more commonly isodiametric to horizontally elongate. The elongate, rather thick-walled vessel segments with porous and obtuse end walls, occur singly or in groups of several to many. These groups are simply radial rows in *O. europaea*, but in the other two species they tend to be in "flames." Parenchyma is in tangential bands in *O. Cunninghamii* and *O. verrucosa* as well as being associated with the vessels in the "flames." In *O. europaea*, however, it is simply terminal and beside the vessels. Tracheids are very thick-walled and the pit mouths are very elongate or simply porous.

The above descriptions are summarized and generalized in a diagrammatic form in Fig. 1.

Jasminum with its uniseriate or rarely biseriate rays composed of vertically elongate cells stands well apart from the other genera studied which uniformly have very well developed multiseriate as well as uniseriate rays. The tracheid-like vessel segments of *Jas-*

¹ Represented by *F. acuminata* Poir., *F. neo-mexicana* Gray, *F. porulosa* Poir., and *F. rhamnifolia* Griseb.

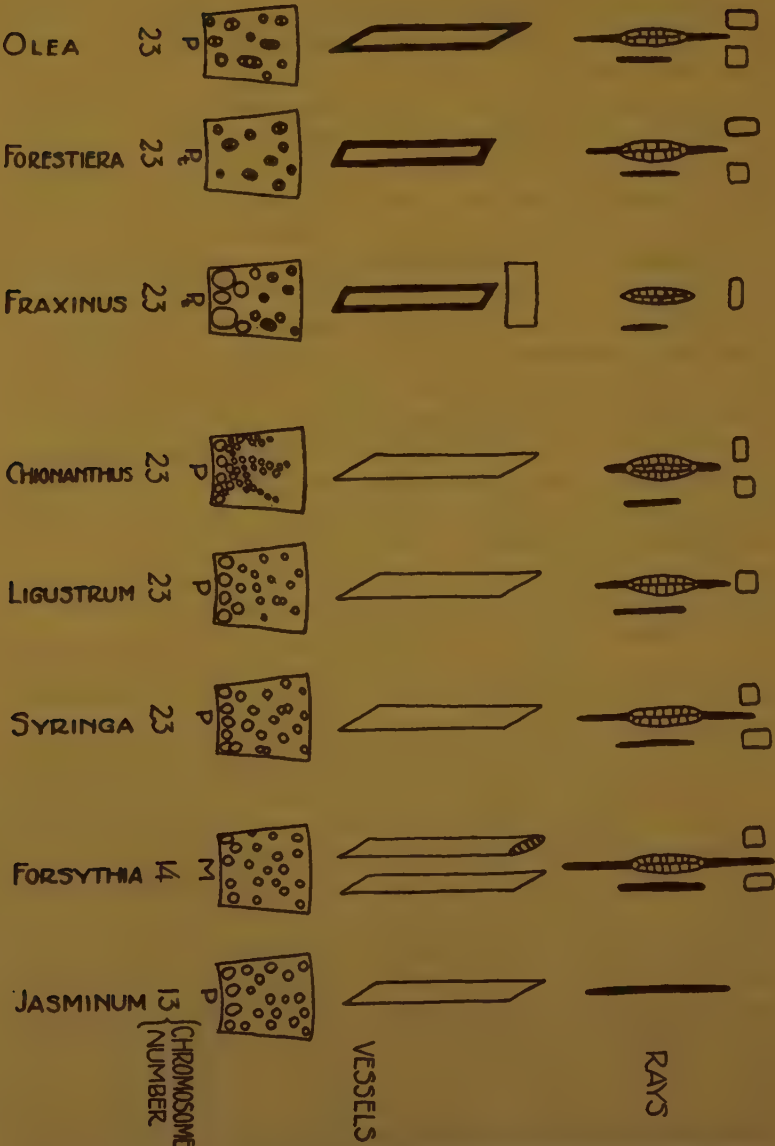
² Represented by *O. europaea* L., *O. Cunninghamii* Hook., and *O. verrucosa* Link.

minum also distinguish it. In both rays and vessel structure *Forsythia* approaches *Jasminum* more closely than do any other genera of the Oleoideae. On the other hand, *Forsythia* differs in such important respects as type of parenchyma distribution, the occasional occurrence of vessel segments with scalariform end walls, and ring porous vessel distribution. Nevertheless, the anatomical structure of *Jasminum* is closer to that of *Forsythia* than that of the other genera, a conclusion also reached by Kohl (1881). That the chromosome numbers of the two is so close is very suggestive, although there is not a complete parallelism because morphologically *Forsythia* seems to approach *Syringa* more nearly than it does *Jasminum*.

In the Oleoideae, *Forsythia* resembles in its diffuse vessel distribution the members of the Ligustrinae in *Syringa*. The reported occurrence of weakly scalariform end walls in *Syringa* strengthens this similarity. Although similar to *Syringa* in these respects it differs in type of parenchyma distribution, and has much longer uniseriate extensions on the multiseriate rays. Thus, although showing many points of similarity to *Syringa*, *Forsythia* is distinguished by the rather commoner occurrence of a decadent scalariform type of end wall, parenchyma between the vessels, and diffuse vessel distribution. That the chromosome number of *Forsythia* is different from that of all the other Oleoideae is of interest, considered in connection with its grafting incompatibility with other genera of this subfamily.

Although *Syringa* has several tendencies in common with *Forsythia*, it shows much closer similarity to *Ligustrum* which in turn is quite close in structure to *Chionanthus*. This grouping is significant because although DeCandolle states that Lilac can be grafted on *Chionanthus*, Chester finds incompatibility of such grafts after the first year. The vessels are of the same type in the three genera, the chief variation being found in vessel arrangement which varies in *Syringa* from diffuse to ring-porous, is ring-porous in *Ligustrum*, and in "flames" in *Chionanthus*. Associated with reduction of length is the decreased occurrence of uniseriate extensions of the multiseriate rays, as well as a tendency toward horizontally rather than vertically elongate marginal cells. Although *Chionanthus* and *Syringa* stand at opposite ends of this range variation, it is so continuous that they appear to be components of the same complex.

Another natural group is formed by *Olea europaea* and *Forestiera*, with their thick-walled, unevenly thickened vessels which tend to occur uniformly in distinctive groups of two or three throughout



TEXT FIGURE 2. ANATOMY OF THE SECONDARY XYLEM IN OLEACEAE
(For explanation see p. 48)

the growth ring. The rays, as well as the parenchyma, are essentially of the *Ligustrum* type, although in the parenchyma there is a tendency toward the formation of tangential rows.

Fraxinus stands very much alone, although it has characters suggesting each of the two previous groups. In the ray type and the ring-porous condition it strongly suggests the *Syringa-Ligustrum-Chionanthus* complex. In parenchyma, and vessel distribution in the summer wood, it resembles the *Olea-Forestiera* group. And making it quite distinct from either group is the occurrence in the spring wood of the very large, thin-walled vessel segments with their transverse, porous end walls. In its chromosome number and morphology it is the same as the other two groups, and by its grafting relationships it shows an affinity for each group.

On the whole there is a suggestive parallelism between chromosome number, grafting relationships and anatomical structure.

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DESCRIPTION OF FIG. 1

The meiotic figures are from aceto-carmine mounts. Magnification 2000 \times . The somatic chromosomes from root tip preparations are magnified 4000 \times .

1. *Fraxinus excelsior*. 1 M. 23 chromosomes.
2. *Fraxinus chinensis rhynchophylla*. 1 M. 69 chromosomes.
3. *Fraxinus pennsylvanica*. 1 M. 23 chromosomes.
4. *Syringa vulgaris* var. 1 M. 24 chromosomes.
5. *Syringa persica laciniata*. 1 M. 22 chromosomes.
6. *Syringa chinensis Saugeana*. 1 M. 36 chromosomes of which about 12 are univalents.
7. *Foresteria acuminata*. 1 M. 23 chromosomes.
8. *Chionanthus virginica*. 1 M. 23 chromosomes.
9. *Ligustrum amurense*. 1 M. 23 chromosomes.

10. *Jasminum fruticans*. 26 somatic chromosomes.
11. *Forsythia intermedia*. 28 somatic chromosomes.
12. *Olea europaea*. 46 somatic chromosomes.

DESCRIPTION OF FIG. 2

Diagrammatic comparison of the wood structure of the genera examined. M = parenchyma between the vessels and associated with the vessels as well as terminal; P = parenchyma terminal and associated with the vessels; Pt = parenchyma terminal and associated with the vessels and forming tangential rows in the summer wood. The rectangles on the right hand side of each multiseriate ray indicate the aspect of the marginal cells in the radial plane. Uniseriate rays and uniseriate extensions of multiseriate rays are indicated in solid black.

CHROMOSOME NUMBERS IN THE GENUS *TILIA*

HAIG DERMEN

With text figures

THE FAMILY Tiliaceae contains about 35 genera and some 400 species (Rehder, 1927). The genus *Tilia* is the only member of the family which is found widely distributed in the north temperate zone, while of the genus *Grewia* only *G. biloba* G. Don extends north as far as northern China.

The fossils that have been recorded are limited to ancestral forms of *Tilia* according to Berry (1923) which have been discovered in the northern hemisphere in early and late tertiary formations. These fossils have been found in Spitzbergen, Alaska, Saghalin Island and in Montana, which would indicate that *Tilia* stock originated somewhere in the far north.

From the Arnold Arboretum plants of ten species and five varieties of *Tilia* and one species of *Grewia* were studied and their chromosome numbers determined. Meiotic figures were drawn from aceto-carmin smear preparations from buds, and somatic chromosomes from root-tip sections. The chromosome numbers of *Tilia* plants were determined from buds and in one case also from root-tips. The number of chromosomes in *Tilia* was $n = 41$ (Fig. 1), making this the highest odd basic number for a genus in plants so far recorded in the published chromosome lists of Tischler (1931) and Gaiser (1930). Eleven plants were diploid forms and four tetraploid forms with $n = 82$ chromosomes. The diploid forms are: *Tilia cordata*, *T. cord. cordifolia*, *T. glabra*, *T. neglecta*, *T. Oliveri*, *T. petiolaris*, *T. platyphyllos laciniata*, *T. plat. vitifolia*, *T. plat. var.* (Fig. 2), *T. vulgaris* (Fig. 1), *T. vulgaris pallida*. The tetraploid forms are: *Tilia amurensis*, *T. insularis*, *T. Maximowicziana* and *T. tuan*.

A single species of the related genus *Grewia* was studied from bud and root-tip preparations to see if it was cytologically related to *Tilia*. The only relationship found was one of size, both *Tilia* and *Grewia* having very small chromosomes, measuring about 1 micron in length and $\frac{1}{2}$ micron in thickness (Figs. 2 and 4). In this species, *G. biloba* G. Don (*G. parviflora* Bge.) the number was $n = 9$ (Fig. 3).

If the Tiliaceae originated from forms with such a low basic number of chromosomes, the number found in *Tilia* must have been derived by both duplication and fragmentation of chromosomes of the basic complex. The possibility of fragmentation is shown in

Grewia where frequently segments are so loosely joined as to be mistaken for whole chromosomes (Fig. 4). Therefore it is suggested that in the case of *Tilia* some of these segments may have been actually broken off and perpetuated as individual chromosomes. The same difficulty was encountered in counting and drawing chromosomes of *Tilia* from root-tip sections where sometimes the number appeared to be 84 instead of 82, though the number of both genera was definitely determined as $n = 41$ for *Tilia* and $n = 9$ for *Grewia*.



Fig. 1



Fig. 2



Fig. 3



Fig. 4

(Explanation in the text)

Some pollen grain measurements were made and practically no difference in size was found between diploid and tetraploid species. *Grewia* with only $n = 9$ chromosomes had pollen grains which were equal to or larger than those of *Tilia*.

Gaiser (1930) lists a number of species from related families of Tiliaceae. The original references were studied to find out whether these species showed any cytological relationship to *Tilia* or *Grewia*.

In the Malvaceae family *Malva moschata* ($n = ?$), *Lavatera thuringiaca* ($n = 20?$), *Althaea sulphurea* ($n = ?$), *Malvastrum capense* ($n = 21$), *Sidalcea neo-mexicana* ($n = 13$), and of the Tiliaceae family, *Entelea palmata* ($n = 8$) and *Sparmannia africana* ($n = 82$) had practically the same size of chromosomes as *Tilia*. In the tribe Hibisceae of the Malvaceae family, *Hibiscus tricuspis* ($n = 40?$), *H. tiliaceus* ($n = 48?$) and *Gossypium barbadense* ($n = 8, 13, 26$) chromosomes are somewhat larger, while in *Hibiscus rosasinensis* ($n = 72?$) they are slightly smaller as compared with *Tilia* chromosomes. The only species, *Theobroma cacao* ($n = 8$), from the family Sterculiaceae has chromosomes of the same size as in *Tilia*. The only striking diversity was found in the size of *Thespesia populnea* ($n = 8, 10, 13$) chromosomes, which are shown to be several times larger than any of the above named species.

If size of chromosomes can be considered of any importance in the relationship of plants certainly these genera from allied families of the Malvales order seem to indicate that they are cytologically related to one another, the only striking exception being *Thespesia populnea* with very large chromosomes. A case similar to this was

found in my studies of the genus *Verbena* of the Verbenaceae family (unpublished data). Here the genus was divided into two distinct groups, one with a basic number $n = 5$ chromosomes and one with $n = 7$, the latter group having chromosomes about 1/10 the size of the former.

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STUDIES ON THE PRECIPITIN REACTION IN PLANTS

I. THE SPECIFICITY OF THE NORMAL PRECIPITIN REACTION

KENNETH S. CHESTER

Plate 42

INTRODUCTION

THE APPLICATION of the theories and methods of animal immunology to plant pathology has been a subject which up to the present has received very little attention. In large part the failure of pathologists to attack their problems from the standpoint of acquired immunity lies in the theoretical and technical obstacles inherent in a biochemical study of plant disease. Such obstacles are due in part to the differences in structure and development between plants and animals, and in part to differences in the type of infection customarily produced. Thus in plants one is dealing with organisms of indeterminate growth in comparison to the determinate growth of the higher animals, there is no circulatory system in plants closely comparable to the blood system of vertebrates, and finally the majority of plant infections are more strictly localized than are many of the animal infections.

Nevertheless, bearing in mind the close ultimate physiological relationship between the plant and the animal cell, their presumably common origin, and their essential functional similarity, it would indeed be strange to find the plant cell reacting to infections in a manner wholly distinct from that of animal cells. The work reported in the present paper was undertaken in an attempt to throw some light upon the question of the reactions of the plant cell in the presence of foreign protoplasm or its constituents, and is a continuation of the writer's previously reported studies of the precipitin reaction in plants (2).

The precipitin reaction has long been an essential technique of animal immunology. Briefly the theory of the reaction is as follows. A foreign protein is injected into the blood of a mammal. As the result of such sensitization, the injected animal acquires an immunity to the specific protein employed. After a short period of time during which the acquirement of immunity has been in progress, blood is withdrawn from the immunized animal, clarified, and pipetted against a solution of the protein originally used for injection. The immune blood now induces a precipitation of the foreign protein from solution, although the precipitating action is absent in the blood of non-immunized animals. The precipitin

reaction is specific against the protein originally employed but is weak or negative against other foreign proteins. In addition to such acquired precipitating power, mammalian blood frequently possesses the ability to precipitate certain proteins with which it has never been sensitized. The substances or properties in the blood which induce such precipitation of foreign proteins with which the animal has been previously sensitized may be called *acquired precipitins*, whereas the substances or properties of the blood inducing the precipitation of proteins against which the animal has not been immunized are called *normal precipitins*.

The present paper reports a study of the normal precipitins in a number of families of woody plants. Its purposes are fourfold, namely, to determine whether in extracts of woody plants one may obtain phenomena comparable to the reactions of mammalian blood in the presence of foreign proteins, to discover whether such reactions are in any manner correlated with the systematic relationships of the plants studied, to aid in the interpretation of the earlier published data upon the precipitin reaction in plants, and finally to clarify to some extent our conception of the nature of the precipitin reaction in plants and its bearing on the processes of plant immunity.

HISTORICAL

The precipitin technique was first applied to plants by Kostoff in 1928 and 1929 (3, 4). The latter, working with a number of species of the solanaceae, observed that in numerous combinations of extracts of Solanaceous species positive reactions were obtained, whereas negative normal precipitin reactions resulted from other extract combinations. The alphabetical order in which Kostoff arranged his tables of reactions does not bring out well the significance of the reactions which he obtained, nor did he attempt to analyze them in the light of possible correlation with systematic position. A rearrangement of Kostoff's data is given in Table 6 for comparison with the results of the present study. From the standpoint of plant immunology this first paper makes a number of important contributions. The author found that after grafting two species of Solanaceae the precipitin reaction of the extracts of the intergrafted plants was markedly increased, that the increase in precipitin potency was strongest in the tissues nearest the graft union and weakened progressively with increasing distance from the graft union, and that the precipitin potency increased from the time of grafting for thirty or forty days, after which time it reached an equilibrium. In addition to the increased precipitin reaction after grafting, Kostoff also observed certain cytological changes,

all of which were interpreted in terms of an acquired immunity as the result of sensitization by the foreign protein of the graft biont.

The only other study of the precipitin reaction in plants following the technique of direct testing of plant against plant is reported by Chester in 1931 (2). In this paper are considered the results of about a thousand tests in the Oleaceae. No normal precipitins were reported among the species used, but a very strong acquired precipitin reaction was obtained in *Syringa vulgaris* hybrids grafted upon *Ligustrum* species as tested against various oleaceous species. The grafted plants were displaying symptoms of disease due to an incompatibility between the lilac scion and the privet stock, and it was found that the morbid processes resulting from such incompatibility so profoundly modified the components of the lilac extract as to alter markedly the precipitin reaction. The morbidity resulting in this case from graft incompatibility was closely resembled by a morbidity from other causes, and in either case there was a marked increase of precipitin potency accompanying the appearance of morbid symptoms in the leaf.

Brief mention should be made of two other bodies of experimentation somewhat related to the work at hand. Mez and his colleagues have published extensive work dealing with an application of the precipitin reaction in animals to plant materials. The results are the basis of the Königsberg phylogenetic tree. The work of Mez and his collaborators has been published in numerous papers in *Botanisches Archiv*, to which the reader is referred for a complete account of the Königsberg studies. The theory of Mez' work is fundamentally different from that of the work of Kostoff and Chester, and hence need be considered no further at this time beyond remarking that the reactions obtained are the reactions of an animal injected with plant proteins and do not represent immunological reactions in which the plant is the organism acquiring an immunity.

A second body of plant immunological research deals with experiments apart from precipitin testing to determine the presence of an acquired immunity in plants subjected to disease. An excellent account of the studies on such acquired immunity in plants is to be found in the recent monograph of Carbone and Arnaudi (1). It may be said in passing that although there have been numerous conflicting reports concerning the acquirement of immunity by plants, there are a number of experiments reported by various French and Italian workers which appear to point definitely to such an acquired immunity. The paper of Carbone and Arnaudi gives a full account of these experiments, and a fairly complete bibliography of the work on acquired immunity in plants.

TECHNIQUE

In the summer of 1931, at the suggestion of Dr. Karl Sax, a set of experiments was undertaken to determine the relationships among the genera of the Pomoideae as indicated by the normal precipitin reaction. The results proved so suggestive that other subfamilies of the Rosaceae and other families of the woody plants were eventually tested to the same end. In all about five hundred reactions were performed, involving twelve genera of the Pomoideae, four genera of the Prunoideae, fifteen species of the genus *Prunus*, two other genera of the Rosaceae, nine genera of the Caprifoliaceae, eight genera of the woody Saxifragaceae, and one genus each of the Leguminosae and the Platanaceae. Except as indicated below all the experiments were performed under uniform conditions, with extracts of the same concentration, tested in the same manner, and with the employment of numerous controls. The technique has been fully described in an earlier paper (2) and only brief mention will be made of it here beyond pointing out the modifications which have been developed.

Fresh leaves of the plants to be tested were collected, weighed, washed in tap water and distilled water, dried, and ground to a fine paste in an unglazed porcelain mortar. To the paste thus obtained was added the required amount of distilled water (four times the weight of the leaves in all the experiments below) and the mixtures were placed in an electric refrigerator at 2° C for twenty-four hours. At the end of this time each mixture was filtered until crystal clear through progressively finer filters, and finally placed in an ice bath. Two to four tenths of a cubic centimeter of the liquid of greater specific gravity was next introduced into a specially-made small test-tube by means of a capillary pipette, and the second extract to be tested was pipetted above so as to form a refractive zone between the two. Readings of the reaction were taken at intervals of one, five, ten, twenty, thirty, and forty minutes, and in most of the experiments reported below readings were independently made by two observers. The utmost care was taken at every step to avoid contamination, and all instruments and glassware were cleaned with a sulphuric acid-potassium bichromate mixture for twenty-four hours followed by repeated washings in water.

The positive tests were strong and well marked. In comparison with the results earlier obtained it may be said that all the readings are minimal. There might have been justification for calling some of the plus two reactions plus three or even plus four, but an attempt was made to increase the significance of the results by using

extreme caution in not overestimating the readings. A study of Plate 42 will indicate the scale employed. Figure 1 represents a negative reaction. The delimitation of the two liquids in the tube is clearly indicated, but there is no trace of a white precipitate at the zone of contact. In Figure 2 is seen a reaction indicated in the tables as a "trace" (t). Figures 3 and 4 illustrate plus one reactions, in Figure 3 the precipitate representing the ultimate intensity of the reaction between the two extracts employed while in Figure 4 the plus one reaction illustrated being merely an early stage of a reaction which after some minutes would have increased to plus two or greater. Figures 5 and 6 represent plus two reactions, Figure 6 being a later stage of the same reaction as pictured in Figure 4. Figures 5 and 6 show well the penetration of the precipitate into the lower extract in little white tortuous rootlets. Later stages of these reactions would show only a uniform cloudiness of the lower extract finally extending upward and involving all the liquid in the tube.

The only essential modification of technique that has been made in the experiments herein reported as compared with the earlier precipitin testing in plants has been that a weaker concentration of extract has been used. Heretofore the ratio of plant tissue to distilled water has been 1:2, while for the purposes of the experiments in the present paper a dilution of 1:4 was found more satisfactory. This change was made necessary by the greater percentage of water in the tissues of the plants earlier studied.

One notable advance in technique, however, has been made. There would be a number of distinct advantages if it were possible to use dried leaf tissues in place of fresh tissues. That it might be possible to obtain comparable results using dried leaves was suggested by Osborne and Wakeman's statement that spinach leaves dried at low temperatures and extracted with ether, alcohol, water, and alkaline solutions yielded results so similar, in analysis and protein extraction, that evidently the constituents of the cells are altered to only a slight degree by drying (5).

In order to test out the possibility of using dried leaves in the precipitin tests, the following experiment was performed. From the results obtained in earlier experiments three plants were so chosen that their inter-reactions would include both positive and negative results. For this purpose *Platanus acerifolia*, *Robinia fertilis*, and *Prunus Armeniaca* var. "Mikado" were arbitrarily chosen. Using fresh leaf preparations, the *Prunus* tests strongly against both the *Robinia* and the *Platanus*, whereas the latter two are negative when tested together. Leaves of these three species were collected and

dried in a Riker plant press for two weeks at a temperature of about 30° C. At the end of this time the leaves were brittle and quite dry. Half of the leaves of each species were then placed in an oven at 60° C for twenty-four hours. Finally each of the six lots of leaves thus dried was ground, extracted, filtered, and tested against the other five extracts. The results were wholly satisfactory. Strong reactions were obtained between the *Prunus* extracts and those of the other species in every case, while the *Platanus* and *Robinia* extracts remained negative to each other. The results of this experiment are shown in Table 1.

TABLE 1. A STUDY OF THE EFFECT ON THE PRECIPITIN REACTION OF THE PREVIOUS DRYING OF THE PLANT TISSUES EMPLOYED

Explanation in the text.

	Platanus (Fresh leaves)	Platanus (Air dried)	Platanus (Oven dried)	Robinia (Fresh leaves)	Robinia (Air dried)	Robinia (Oven dried)	Prunus (Fresh leaves)	Prunus (Air dried)	Prunus (Oven dried)
<i>Platanus acerifolia</i> (Fresh leaves)	-			-			3		
<i>Platanus acerifolia</i> (Air dried leaves)		-	-		-	-	3	3	
<i>Platanus acerifolia</i> (Oven-dried leaves)		-	-		-	-	2	2	
<i>Robinia fertilis</i> (Fresh leaves)	-			-			3		
<i>Robinia fertilis</i> (Air dried leaves)		-	-		-	-	2	2	
<i>Robinia fertilis</i> (Oven dried leaves)		-	-		-	-	2	2	
<i>Prunus Armeniaca</i> (Fresh leaves)	3			3			-		
<i>Prunus Armeniaca</i> (Air dried leaves)		3	2		2	2	-	-	
<i>Prunus Armeniaca</i> (Oven dried leaves)		3	2		2	2	-	-	

It will be seen that there is a slightly higher reaction accompanying the use of air dried leaves in one case, and although the distinction was too fine to be indicated by the difference of a plus sign, it should be noted that the extracts from air dried leaves always tested slightly more strongly than those from the oven-dried leaves. The reactions as a whole were slightly weaker than those where fresh leaves were used, but the difference is not considered significant. It was impossible to equalize the concentration of the two types of extract with certainty, since the percentage of water in the fresh leaves was not known. In the case of the fresh leaves the weight ratio of leaf tissue to water of extraction was as 1 : 4, while with the dried leaves the corresponding ratio selected was 1 : 10.

The ability to utilize dried leaves in precipitin testing has, as has been indicated, a number of advantages. It is thus possible to continue work with the deciduous woody plants throughout the winter; moreover one may work with specimens shipped in a dried condition from all parts of the globe; it is possible to employ dried herbarium specimens in testing; manipulation of dried material is much easier than of fresh leaves with especial respect to grinding; the extracts made with dried leaves filter much more readily than those made with fresh leaves; and finally adjustment of the water concentration of the extracts may be made with much greater accuracy. The fact that experiments may be performed with essentially the same results whether one uses dried or fresh leaves does not argue against the hypothesis of the protein nature of the reaction according to the evidence of Osborne and Wakeman as cited above.

EXPERIMENTAL DATA

The actual experimental results are shown in the following tables (Tables 2-6). With them is included for comparison a synopsis of the results obtained by Kostoff on the Solanaceae, rearranged according to the systematic position of the genera.

READING AND INTERPRETATION OF EXPERIMENTAL DATA

A word of interpretation is a necessary preliminary to a study of the tables. In contrast to the work of Mez and others, an increasing positive reaction here indicates an increasing degree of divergence from the type. The negative reaction (-) appears to have a double significance. A study of Table 2 will bring this out. In the upper left-hand corner there is a block of negative reactions indicative of the homogeneity of the Pomoideae. Traces of reactions appear in a few instances, but for the main part the results are uniformly

TABLE 2. NORMAL PRECIPITIN REACTIONS IN THE POMOIDEAE AND RELATED GENERA
Explanation in the text.

	<i>Spiraea virginiana</i>	<i>Cotoneaster acutifolia</i>	<i>Mespilus germanica</i>	<i>Pyracantha coccinea</i>	<i>Crataegus punctata</i>	<i>Sorbus aucuparia</i>	<i>Aronia melanocarpa</i>	<i>Photinia villosa</i>	<i>Stranvaesia Davidiana</i>	<i>Chaenomeles lagenaria</i>	<i>Malus prunifolia</i>	<i>Malus Tschonoskii</i>	<i>Pyrus nivalis</i>	<i>Amelanchier oblongifolia</i>	<i>Rosa rugosa</i>	<i>Prunus Armeniaca</i>	<i>Platanus acerifolia</i>	<i>Robinia fertilis</i>	<i>Philadelphus grandiflorus</i>
<i>Spiraea virginiana</i>	-	-	-	-	-	-	-	t	t	-	-	-	-	-	1	2	1	1	1
<i>Cotoneaster acutifolia</i>	-	-	-	t	2	-	-	t	t	-	t	-	-	t	-	2	1	1	1
<i>Mespilus germanica</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Pyracantha coccinea</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Crataegus punctata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Sorbus aucuparia</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Aronia melanocarpa</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Photinia villosa</i>	t	t	-	-	-	-	-	-	-	-	-	-	-	-	1	2	1	1	1
<i>Stranvaesia Davidiana</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	1	1
<i>Chaenomeles lagenaria</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	1	1
<i>Malus prunifolia</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	1	1
<i>Malus Tschonoskii</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	1	1
<i>Pyrus nivalis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	1	1
<i>Amelanchier oblongifolia</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	1	1
<i>Rosa rugosa</i>	1	-	-	2	t	-	-	1	2	-	2	-	-	-	-	2	2	1	2
<i>Prunus Armeniaca</i>	2	-	-	2	t	-	-	2	-	-	2	2	-	-	2	-	3	3	3
<i>Platanus acerifolia</i>	t	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	1	1	1
<i>Robinia fertilis</i>	t	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	1	1	1
<i>Philadelphus grandiflorus</i>	t	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	1	1	1

negative. The reaction steadily increases as one passes farther from the Pomoideae, beginning with *Spiraea* which is very closely allied to the Pomoideae, passing to *Rosa* which is somewhat more distantly related to the Pomoideae, and finally reaching *Prunus* with the strongest reaction of all, as might well be expected since of all the subfamilies of the Rosaceae the Prunoideae are farthest removed from the Pomoideae. As we pass outside the family, however, the reaction again diminishes. This phenomenon has been observed in a number of cases (cf. Tables 3 and 4). In other words, reasoning from the data thus far available, there appears to be a degree of divergence which results in a maximum reaction. If this degree of divergence be either exceeded or decreased the reaction appears to diminish in intensity. One is immediately struck by the analogy to the "zone phenomenon" in animal immunology, where there is an optimum concentration for reaction, and where if this optimum be passed in either direction the reaction diminishes. There is one significant difference in the plant phenomenon, however, namely that whereas in the zone phenomenon one has to do solely with a quantitative optimum, in the case at hand it appears to be a qualitative difference which determines the optimum of reaction. Thus in the normal plant precipitin reactions the optimum condition for reaction, according to the hypothesis above, implies a qualitative difference in the reacting substances which must be neither too great nor too small. Hence, one would infer that a negative reaction might imply a very close relationship or a very great divergence, whereas a positive reaction would involve a definite degree of affinity. It would thus be impossible from a single reaction to judge the degree of affinity of two plants; such judgement could only follow from a consideration of the reactions of the plant in question in relation to the reactions of a number of related species. As a case in point, the first reactions performed with *Prunus* involved eight species. From the reactions thus obtained it was very difficult to arrive at a logical interpretation. Seven additional species of *Prunus* were chosen and tested against the original species and against one another. The result was that the seven additional species offered connecting links and transitions of such value that the fifteen species at once fell into a logical order, in fact an order which with but one exception agrees with the order of arrangement accepted by present-day taxonomists of the genus.

One other fact must also be taken into consideration. As is well known to taxonomists, groups of plants vary among one another in *variability*. A given character which may be very uniform in one heterogeneous group may be very variable in another more homo-

geneous group. Such is the case with the precipitin reaction. Because one finds the Caprifoliaceae to be rather uniformly negative among themselves whereas the genus *Prunus* exhibits a high degree of variability does not necessarily imply that the Caprifoliaceae as a group are more homogeneous than the genus *Prunus*. *Prunus* may be homogeneous in many characters, but in its precipitin re-

TABLE 4. NORMAL PRECIPITIN REACTIONS IN THE SAXIFRAGACEAE

Explanation in the text.

	<i>Philadelphus grandiflorus</i>	<i>Fendlera Wrightii</i>	<i>Jamesia americana</i>	<i>Deutzia scabra plena</i>	<i>Hydrangea paniculata</i>	<i>Schizophragma hydrangeoides</i>	<i>Itea virginiana</i>	<i>Ribes petraeum</i>	<i>Prunus Armeniaca</i>	<i>Robinia fertilis</i>	<i>Photinia villosa</i>	<i>Platanus acerifolia</i>
<i>Philadelphus grandiflorus</i>	-	-	-	-	-	-	t	2	2	1	-	t
<i>Fendlera Wrightii</i>	-	-	3	1	-	-	2	3	3	2	2	1
<i>Jamesia americana</i>	-	3	-	-	-	t	-	2	3	t	1	-
<i>Deutzia scabra plena</i>	-	1	-	-	-	t	-	1	t	2	-	-
<i>Hydrangea paniculata</i>	-	-	-	-	-	1	t	2	2	2	-	-
<i>Schizophragma hydrangeoides</i>	-	-	t	t	1	-	1	2	3	2	-	t
<i>Itea virginiana</i>	t	2	-	-	t	1	-	2	2	1	1	t
<i>Ribes petraeum</i>	2	3	2	1	2	2	2	-	-	2	3	2
<i>Prunus Armeniaca</i>	2	3	3	t	2	3	2	-	-	3	2	3
<i>Robinia fertilis</i>	1	2	t	2	2	2	1	2	3	-	-	-
<i>Photinia villosa</i>	-	2	1	-	-	-	1	3	2	-	-	-
<i>Platanus acerifolia</i>	t	1	-	-	-	t	t	2	3	-	-	-

action it exhibits a remarkable variability. Whatever the character chosen as fundamental in a taxonomic study, the same phenomenon occurs. Each group must be judged by itself and its phylogenetic relationships must at present necessarily be determined by no one character but by the bulk of evidence yielded by all characters, morphological, anatomical, cytological, genetic, and physiological.

A COMPARISON BETWEEN THE SYSTEMATIC RELATIONSHIPS
INDICATED BY THE EXPERIMENTS AND THE RELATION-
SHIPS INDICATED BY MORPHOLOGICAL TAXONOMY

In projecting the normal precipitin reaction in plants as an aid in systematic studies of the plant groups it is of utmost importance to ascertain the degree of correlation which exists between the relationships as indicated by the reaction and those accepted by modern taxonomists. As has been pointed out an exact parallel with morphological systems is neither found nor to be expected.

TABLE 5. NORMAL PRECIPITIN REACTIONS IN THE
CAPRIFOLIACEAE

Explanation in the text.

	<i>Sambucus canadensis</i>	<i>Viburnum cassinoides</i>	<i>Symphoricarpus mollis</i>	<i>Dipelta ventricosa</i>	<i>Abelia Zanderi</i>	<i>Linnaea borealis</i>	<i>Kolkwitzia amabilis</i>	<i>Diervilla florida</i>	<i>Lonicera Myrtillus</i>	<i>Pyracantha coccinea</i>	<i>Deutzia scabra plena</i>	<i>Platanus acerifolia</i>
<i>Sambucus canadensis</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Viburnum cassinoides</i>	-	-	-	1	1	-	-	-	-	-	-	-
<i>Symphoricarpus mollis</i>	-	-	-	t	-	-	-	-	-	-	-	-
<i>Dipelta ventricosa</i>	-	1	t	-	-	-	1	-	-	-	t	-
<i>Abelia Zanderi</i>	-	1	-	-	-	-	-	-	-	1	t	-
<i>Linnaea borealis</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Kolkwitzia amabilis</i>	-	-	-	1	-	-	-	-	-	-	-	-
<i>Diervilla florida</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Lonicera Myrtillus</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Pyracantha coccinea</i>	-	-	-	-	1	-	-	-	-	-	-	-
<i>Deutzia scabra plena</i>	-	-	-	t	t	-	-	-	-	-	-	-
<i>Platanus acerifolia</i>	-	-	-	-	-	-	-	-	-	-	-	-

However, the value of the reaction as a systematic tool depends upon a general conformity with our present knowledge of the main trends in taxonomy, and the present section will hence be devoted to a consideration of the question of whether such general conformity does exist. The discussion of the results of the precipitin experiments in relation to the systematic position of the plants tested must necessarily be confined to the broader, more pronounced re-

TABLE 6. KOSTOFF'S RECORD OF NORMAL PRECIPITIN REACTIONS IN THE SOLANACEAE, WITH THE GENERA ARRANGED ACCORDING TO THE SYSTEMATIC TREATMENT OF ENGLER-GILG—Explanation in the text.

	Lycium barbarum	Solanum nigrum	Solanum dulcamara	Solanum melongena	Solanum tuberosum	Solanum lycopersicum	Solanum tuberosum	Capsicum pyramidale	Physalis peruviana	Datura Wrightii	Datura ferox	Nicotiana suaveolens	Nicotiana Langsdorffii	Nicotiana Tabacum	N. rustica × Tabacum	Nicotiana rustica	Nicotiana alata	Nicotiana paniculata	Nicotiana glauca	Nicotiana Rusbyi	Petunia violacea	Salpiglossis sinuata
Lycium barbarum	-	-	3	t	-	-	-	2	-	2	2	t	-	t	-	-	-	-	-	-	2	-
Solanum nigrum	-	-	-	-	-	-	?	4	2	4	4	t	-	-	-	2	-	-	1	3	-	3
Solanum dulcamara	3	-	-	-	-	-	-	4	4	4	4	-	-	-	-	-	-	-	-	-	-	4
Solanum melongena	t	-	-	-	-	-	-	2	-	4	4	-	-	-	-	-	-	-	-	1	-	3
Solanum lycopersicum	-	-	-	-	-	-	-	1	-	4	4	1	2	-	-	t	2	-	-	-	-	3
Solanum tuberosum	-	?	-	-	-	-	-	-	-	4	4	-	-	-	-	-	-	-	-	-	-	3
Capsicum pyramidale	2	4	4	2	1	-	-	-	-	t	-	-	2	1	-	1	1	1	t	t	-	-
Physalis peruviana	-	2	4	-	-	-	-	-	-	-	-	-	-	3	-	3	-	-	-	-	-	-
Datura Wrightii	2	4	4	4	4	4	4	t	-	-	-	?	-	-	-	-	-	-	-	-	-	-
Datura ferox	2	2	-	-	1	-	-	-	-	-	-	2?	-	-	-	-	-	-	-	-	-	-
Nicotiana suaveolens	t	t	-	-	-	-	2	-	-	2?	?	-	-	1	-	-	-	-	-	3	-	-
Nicotiana Langsdorffii	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	3	1	-
Nicotiana Tabacum	t	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	t	-	2	-	4
Nicotiana rustica × Tabacum	-	-	-	-	-	-	-	1	3	-	-	-	-	-	-	-	-	-	-	1	-	-
Nicotiana rustica	-	2	-	-	-	-	t	1	-	-	-	-	-	-	-	-	-	-	-	1	-	4
Nicotiana alata	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Nicotiana paniculata	-	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	t	-	-
Nicotiana glauca	t	1	-	-	-	-	-	1	-	-	-	-	-	t	-	-	-	-	-	-	-	3
Nicotiana Rusbyi	-	3	3	1	1	-	-	t	2	-	-	3	3	2	1	1	1	t	-	-	3	-
Petunia violacea	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	3	-	-
Salpiglossis sinuata	-	3	4	3	3	-	-	-	-	-	-	-	-	4	-	4	-	t	3	-	-	-

lationships of the groups, since a detailed analysis of the value of each reaction would be possible only to a monographer of the respective groups equipped with a very extensive knowledge of the evidences of relationship yielded by several methods of approach.

Referring to Table 2 one is first impressed by the relative homogeneity of the Pomoideae. This point is in conformity with the findings of taxonomists in general that the Pomoideae as a whole represent a well marked and uniform subfamily. The one strong reaction indicated, that of *Mespilus* plus *Crataegus*, is susceptible to a somewhat different explanation than any of the other reactions indicated in this paper. *Mespilus* and *Crataegus* are assumed to be very closely allied. One would expect, if this be true, a negative reaction. The plant of *Mespilus* chosen, however, had been propagated by grafting upon *Crataegus*, and the reaction may very well represent a modification of the normal immunity. Passing outside the subfamily, the Spiraeoideae as represented by *Spiraea virginiana* show a close affinity to the Pomoideae, the Rosoideae would be somewhat farther removed, while the Prunoideae appear to be farthest removed of all from the Pomoideae. Such an arrangement as indicated by the precipitin reaction conforms to the opinion of Rehder and others that the Spiraeoideae are relatively close to the Pomoideae on the basis of morphology, while the Rosoideae and the Pomoideae are more divergent in the order named. It may be claimed that such a comparison as the above, based upon a single species of each subfamily, is unwarranted. It is indeed possible that a selection of numerous species of each subfamily would show variation among themselves in their reactivity toward the Pomoideae, but in the absence of more extensive data upon this point one may merely note that the species chosen at random do show such a progressive removal from the Pomoideae as would be expected from a knowledge of the taxonomy of the group involved. The other three genera chosen for testing against the Pomoideae are all hypothetically too far removed from that subfamily to show marked reactions.

Passing to the Prunoideae (Table 3) one is first impressed by the remarkable variability evidenced as compared with the Pomoideae. The Prunoideae as a whole are a much more complex group than the Pomoideae and such greater variability might well be anticipated. *Prunus spinosa* and *P. insititia* exhibit reactions very similar in general, conforming with their close morphological relationship. Moreover the Euprunus group (represented here by *P. spinosa*, *P. insititia*, *P. domestica*, *P. cerasifera*, and *P. salicina* \times *P. Simonii*) as a whole are practically negative among one another but positive

to the remainder of the genus. The transition from the *Euprunus* group to *P. maritima* in *P. salicina* \times *P. Simonii* is readily interpreted in the light of the close relationship of *P. maritima* to the Plums. The reactions of *P. Armeniaca*, *P. Persica*, and *P. Davidiana* in general are somewhat less uniform, although a relationship between *P. Armeniaca* and *P. Persica* is apparent. *P. Davidiana* diverges curiously, a point which might well be of interest to a student of the group. The Cherries as a group, *P. pumila*, *P. serrulata*, and *P. avium*, are well set off from the preceding members of the genus and are mutually negative as would be anticipated. Finally the *Padus* group, *P. serotina* and *P. Padus*, are mutually negative and show their only affinities with the Cherries, which is in accordance with taxonomic findings.

Certain exceptional reactions in the genus are of interest. Among these should be mentioned the aberrance of *P. hortulana* and the distinction among the Peaches already indicated. That *P. Persica* should react positively with *P. Davidiana* is certainly worthy of note. Finally as one passes outside the genus the reactions diminish in accordance with the hypothesis previously pointed out.

In the Saxifragaceae (Table 4) occur a number of interesting reactions. As a whole the group of reactions exhibits a parallel with the taxonomic treatments. *Ribes* is by far the most aberrant genus, as would be expected, with *Itea* following closely after. The strong reaction of *Fendlera* and *Jamesia* is worthy of comment, as the two genera are considered to be rather closely allied, while one is somewhat surprised at the slight divergence of *Hydrangea* and *Schizophragma*.

The Caprifoliaceae (Table 5) as a whole are rather disappointing from the standpoint of the precipitin reaction. The group is rather heterogeneous and a number of strong reactions were anticipated. However, as has been already suggested, the groups selected would be expected to vary from one another in variability and the technique would necessarily be of more value in some groups than in others. *Sambucus* is taxonomically very distinct from the rest of the family. Hypothetically its negative reactions may well indicate too great a divergence to result in positive tests. *Viburnum* of all the genera considered is most reactive, which accords with its intermediate position between *Sambucus* and the rest of the family. The *Dipelta-Kolkwitzia* reaction is puzzling, but *Dipelta* is rather aberrant and its aberrance as expressed by the precipitin reaction may well be greater than that which would be expected from a study of morphological structure.

Finally a consideration of the Solanaceae (Table 6) is of interest.

It should be recognized at the start that the reactions of the Solanaceae as here indicated were performed by a different worker, under different experimental conditions, and hence may not be strictly comparable to the results in the other tables. Attention is first directed to the reactions of the genus *Nicotiana*. As a whole the genus is very uniform, *N. Rusbyi* alone being divergent. The negative reactions of the latter with the other twelve-chromosome members of the genus, *N. glauca* and *N. paniculata*, may well be of significance, but its strong reactions with the remainder of the genus are problematical. The species of *Solanum* are uniformly negative with one another and thereby stand apart as a homogeneous group fairly closely allied, according to the reactions, with *Nicotiana*, *Capsicum* and *Physalis*, generally accepted as very close taxonomically, are mutually negative, and on the whole rather strongly set off from the neighboring genera. *Salpiglossis* and *Petunia* exhibit a like relationship, being mutually negative but distinct from all the other genera. Of all the groups considered the Solanaceae is probably the most complex and poorly defined. It is likely that many of the species are the products of a reticular phylogeny, and if this be true, the reactions are of particular interest. It may very well be that the group is so large that some of the more peripheral negative reactions represent divergence rather than affinity, but the positive reactions on the whole show a reasonable correlation with what is known of the relationships of the family.

It is of value at this point to consider the theoretical results of a series of precipitin tests in a circumscribed group in order to form a clearer conception of the correlation between the theoretical expectation and the experimental yield. Assuming a group of five species capable of being arranged in a linear series, each of the assumed species being equidistant in all characters from the two adjacent species, the reactions obtained would theoretically be of the general form:

	A	B	C	D	E
A	-	t	1	2	3
B	t	-	t	1	2
C	1	t	-	t	1
D	2	1	t	-	t
E	3	2	1	t	-

The significant facts to draw from such a theoretical table are that in the reactions of such an ideal group there would be a concentra-

tion of the strongest reactions in the upper right-hand and lower left-hand corners, that there would be a path of negative reactions extending along the opposite diagonal, and that the reactions would progressively increase in strength as one passed from any point on the diagonal toward the opposite corners of the table. The situation pictured, however, would rarely if ever obtain, since circumscribed groups of species or genera customarily tend to fall into a number of subgroups, each subgroup being relatively homogeneous and distinct as a body from the other subgroups. Selecting the genus *Prunus*, since that is the group which has been most thoroughly investigated from the standpoint of the precipitin reaction, one may plot a theoretical expectation for a group of species conforming in main outlines to this genus. Rehder's treatment of the genus (6) would divide the species considered in the following manner. The first eight species indicated in the table would fall into a single subgenus *Prunophora*. This group of eight may be further subdivided into three subgroups, a first subgroup (*Euprunus*) including *P. spinosa* to *P. salicina* \times *P. Simonii*, a second subgroup represented by *P. maritima* and *P. hortulana* (*Prunocerasus*), and a third subgroup (*Armeniaca*) containing *P. Armeniaca*. *P. Persica* and *P. Davidiana* would represent the second subgenus (*Amygdalus*), *P. pumila*, *P. serrulata*, and *P. avium* the third (*Cerasus*), and *P. serotina* and *P. Padus* the fourth (*Padus*). In other words the species considered may be divided into six groups, consisting of 5, 2, 1, 2, 3, and 2 species respectively. If the theoretical yield of a body of fifteen species so divided be plotted, the resulting chart would have the general form of Table 7.

By comparing this theoretical arrangement of reactions with the actual reactions obtained in *Prunus* (Table 3) one immediately sees the resemblance. In the upper left-hand corner of each there is a block of negative signs indicative of the close relationship of the *Euprunus* group. The hybrid "Wickson" Plum (*P. salicina* \times *P. Simonii*) alone begins to diverge from the *Euprunus* type. The path of negative reactions from upper left to lower right is well marked on both tables as is also the concentration of the more powerful reactions in the opposite corners. It will be observed that in the table of *Prunus* reactions the arrangement of Rehder was strictly followed. Several factors tend to cause some degree of divergence from the ideal grouping. Thus the ideal table assumes that the subgroups are perfectly homogeneous, that they are all equidistant from their adjacent subgroups, and that they can be arranged in a linear series. In actual practice none of these conditions obtains. The real relationships between the fifteen selected species

of *Prunus* could probably be represented only by a three-dimensional figure in part dendritic in form and in part reticular. Convergence undoubtedly accounts for some of the similarities. In practice these several factors lead to a certain amount of variation from the ideal distribution, but that the experimental chart in its general features conform strikingly to the ideal chart affords definite evidence of the value of the method in taxonomy and of the specificity of the reaction in immunology.

TABLE 7. THEORETICAL EXPECTATION OF PRECIPITIN REACTIONS IN AN IDEAL GROUP OF THE GENERAL STRUCTURE OF THE GROUP OF PRUNUS SPECIES TESTED (TABLE 3)

Explanation in the text.																
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
A	-	-	-	-	-	t	t	1	2	2	2	2	2	2	2	
B	-	-	-	-	-	t	t	1	2	2	2	2	2	2	2	
C	-	-	-	-	-	t	t	1	2	2	2	2	2	2	2	
D	-	-	-	-	-	t	t	1	2	2	2	2	2	2	2	
E	-	-	-	-	-	t	t	1	2	2	2	2	2	2	2	
F	t	t	t	t	t	-	-	t	1	1	2	2	2	2	2	
G	t	t	t	t	t	-	-	t	1	1	2	2	2	2	2	
H	1	1	1	1	1	t	t	-	t	t	1	1	1	2	2	
I	2	2	2	2	2	2	1	1	t	-	-	t	t	t	1	1
J	2	2	2	2	2	2	1	1	t	-	-	t	t	t	1	1
K	2	2	2	2	2	2	2	1	t	t	-	-	-	t	t	
L	2	2	2	2	2	2	2	1	t	t	-	-	-	t	t	
M	2	2	2	2	2	2	2	1	t	t	-	-	-	t	t	
N	2	2	2	2	2	2	2	2	1	1	t	t	t	-	-	
O	2	2	2	2	2	2	2	2	1	1	t	t	t	-	-	

Finally lest it be asserted that the distribution of reactions obtained might well have been fortuitous, one may compute the probability that seventy-five reactions distributed at random might as closely resemble the ideal distribution as do the experimental results in Table 3. It will be found that the probability of such a distribution by chance alone is exceedingly small.

From the comparison which has been made between the relationships indicated by the reaction and those indicated by recent taxonomic studies, one can now reach a conclusion as to the systematic value of the reaction. It has been seen that on the whole the reactions are expressive of the same broad phylogenetic trends as are indicated by the conventional taxonomic methods. Incompatibilities do exist, although for the main part they are minor as compared with the main features of agreement. That there are such incompatibilities is no more characteristic of the precipitin technique than of other techniques of phylogenetic investigation, and the precipitin reaction thus offers to the intensive monographer at the same time a technique for shedding light upon his more debatable relationships, and a challenge in interpretation.

EVIDENCE AS TO THE NATURE OF THE REACTION

The taxonomic value of the reaction having been pointed out, it is desirable at this point to consider the evidence yielded by the experiments in hand as to the nature of the reaction. The precipitin technique may be interpreted either as a purely physical phenomenon, as a reaction of some non-specific chemical compound of the extracts, or finally as a reaction of the specific proteins of the extracts. It is important to know which of these interpretations is applicable not only in determining the stress which is to be laid upon the reaction from the phylogenetic standpoint, but also in evaluating the work which has been done in applying the technique to a study of plant immunity. In this, as in most other biological problems, the solution depends upon the evidence yielded by two main lines of investigation, the descriptive and the analytical. The present paper treats of the precipitin reaction from the descriptive approach. Before a final conclusion is reached as to the nature of the reaction and its consequent value in taxonomy, immunology, and parasitology, the analytical method must be applied. The reaction must be subjected to an intensive study employing the techniques of biochemistry. Such a study is now in progress, and upon the results will depend the final interpretation of the precipitin reaction in plants. Meanwhile, however, it is instructive briefly to point out the facts which have been yielded by the descriptive mode of attack as having a bearing upon the solution of the problem as to the nature of the reaction.

With regard to the hypothesis that the reaction may be due to purely physical variables, the evidence at present indicates that such is not the case. Kostoff (4), in an extensive series of pH determinations in the solanaceous extracts with which he worked,

showed that the precipitin reaction bears no relation to the pH of the extracts employed. The temperature of the extracts has been so fully controlled that it could not conceivably function as a cause for the precipitation. That the concentration of the extracts alone does not account for the reaction is evidenced by the facts that minor dilutions do not appreciably affect the reaction and that the progressive dilution of one or both of the extracts merely progressively weakens the precipitation. Furthermore, it is immaterial which extract be pipetted above the other in testing. The relative position of the extracts may be reversed without affecting the potency of the reaction. It is difficult to conceive of any other purely physical variable which could be responsible for the reaction.

With a purely physical explanation of the reaction thus eliminated one is forced to conclude that the precipitation is due either to the action of some non-specific chemical component of the extracts, or to a relatively specific substance of enzymatic nature, or to the highly specific proteins. It would exceed the bounds of scientific caution at present to attempt to ascribe the precipitin reaction to one of these three groups of substances. The specificity of the reaction and its general agreement with the complexity of the taxonomic treatments inclines one to the belief that specific proteins are involved. On the other hand, some of the reactions, such as those of *Prunus*, *Ribes*, and *Robinia* in Table 4 lead one to the suspicion that possibly some non-specific compound is acting in a rather complex fashion to produce the precipitates. As has been indicated above the solution of the problem of the nature of the reaction ultimately depends upon a chemical analysis of the reaction and it is more prudent to suspend decision until the results of the biochemical investigation are available.

PRACTICAL APPLICATION OF THE PRECIPITIN REACTION

A word should be introduced at this point regarding the practical application of the precipitin technique in systematic studies of plant groups. It has been shown in the preceding pages that the reaction bears a definite relation to the systematic position of the plants studied, and that this relation is too well correlated with taxonomic positions to be accidental. That we have in the precipitin reaction an additional taxonomic tool is apparent. The technique is somewhat tedious in application and as a result its employment will necessarily be limited to such debatable phylogenetic problems as must be attacked from every available angle. If the reaction is truly protein in nature it is conceivable that the evidence obtained is more fundamental than that yielded by a study of secondary char-

acters. In its present state of development the precipitin technique is necessarily limited to small groups and will prove to be much more sensitive in some groups than in others. A more explicit statement of the value of the reaction in systematic studies awaits a final determination of the nature of the reaction from the biochemical standpoint.

The method of direct precipitin testing in plants is not comparable to the technique involving the sensitization of animals with plant extracts. If proteins are involved the direct technique as outlined in the present paper has a number of advantages over the older technique. Among these advantages are the greater simplicity of application, the freedom from errors produced by the variability in the experimental animals, and the absence of more fundamental errors due to the fact that an animal sensitized to a given species of plant will react positively to the extract from a widely separated species containing an homologous protein. For as Wells and Osborne have pointed out (7) the same protein may occur in widely separated species, accompanying the proteins upon which depend the specificity of the respective species. The direct precipitin method reveals only the *differences* in reactivity of the extracts, homologous reactive substances being neutralized in the process of extraction. On the other hand, in its present form the direct precipitin technique is certainly much less sensitive than the blood technique, although the results as indicated in Tables 2-6 demonstrate that an application is useful in limited plant groups.

In conclusion it may be said that the positive reactions yielded by plant extracts in the presence of foreign extracts is indicative of a phase of immunity against disease which has as yet received scant attention in plant pathology. It is well known that susceptibility and immunity in plants in many cases depend on more than mechanical obstructions to the invading organism, the presence of toxins, or the absence of conditions vital to the development of the parasite. An application of the principle of incompatibility as developed above may well afford an answer to some of the heretofore inexplicable problems of the parasitology of plants.

SUMMARY

1. The present paper describes a series of tests of the direct normal precipitin reactions in a number of families of woody plants for the purpose of determining the specificity of the reaction and its consequent relation to applications of the method in phylogeny and immunology.

2. A marked advance in technique, namely the ability to utilize

dried leaf tissues in the tests, is described, and its advantages over the use of fresh tissues are pointed out.

3. In general the results of the experiments performed indicate a clear-cut parallel between the systematic relationships as indicated by the precipitin reaction and the main trends of relationship as indicated by the conventional methods of taxonomy. The divergences from such a parallel are no greater than are found in the comparison of the relationships indicated by any two systematic methods. Uniform groups of plants are in general characterized by homogeneity in reaction and absence of mutual reactivity, whereas the reactions steadily increase as one passes farther from the type originally selected, reaching a maximum at a given distance from the type, and then again disappearing as the divergence of the plants hypothetically becomes too great to be expressed in reaction.

4. An analysis is made of the nature of the reaction on the basis of the evidence yielded by the study of normal precipitins. The hypothesis that the reaction may be due to purely physical variables is shown to be untenable, and attention is hence directed to the influence of specific components of the extracts studied.

5. The parallel obtained between the results of the precipitin tests and the accepted systematic relationships indicates the value of an application of the precipitin technique to intensive studies of circumscribed plant groups both in confirming the results of systematic investigations employing other methods of attack and in shedding light upon the more debatable relationships between certain genera and species.

6. The specificity manifested by the normal precipitin reaction affords definite indication of the value of an application of the technique in a study of the nature of immunity to disease in plants.

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The suggestions and criticisms of a number of the members of the staff of the Arnold Arboretum have assisted in the study herein reported. Acknowledgement is particularly due to Dr. Karl Sax who originally proposed that the work be undertaken and who aided materially in the selection of plants for investigation, to Professor J. H. Faull, and Dr. Edgar Anderson for numerous helpful suggestions, and to Dr. Ivan M. Johnston for valuable assistance in appraising the experimental data from the systematic viewpoint.

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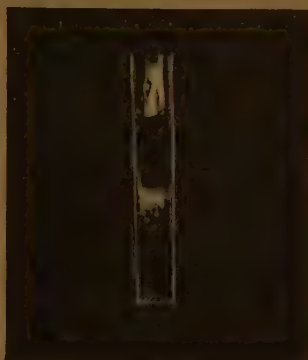
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STUDIES ON THE PRECIPITIN REACTION IN PLANTS

THE OCCURRENCE IN THE UNITED STATES OF CRYPTOCOCCUS FAGI (BAER) DOUGL., THE INSECT FACTOR IN A MENACING DISEASE OF BEECH

JOHN EHRlich

THE BEECH SCALE, *Cryptococcus fagi*, has long been known in Europe as a common pest on *Fagus sylvatica* and its varieties. It has been found in practically every country of western Europe. Sporadically infestations have at times been followed by an extensive killing of Beech, but elsewhere no important damage has resulted. Studies on destructive epidemics have yielded some evidence that the immediate killing agents were certain fungi, species unable to secure a foothold on healthy uninjured bark, but capable of causing much damage if entrance has been made possible by the scale.

The first discovery of the scale in America was reported by Hewitt in 1914 on ornamental European Beeches and our native *Fagus grandifolia* in the vicinity of Halifax, Nova Scotia. Evidence was presented which indicated that it had been there since about 1890. Subsequent notes on its spread indicate that it is at present general throughout the Maritime Provinces of eastern Canada. But until now there has been no report of its having reached the United States.

In the earlier stages of the outbreak in Nova Scotia no serious damage to the Beech was noted, but eventually there set in a destruction of Beech on a wide scale and in alarming proportions. A pathological reconnaissance of the forests of Nova Scotia made in 1929 by Dr. J. H. Faull of the Arnold Arboretum, Harvard University, led him to conclude that the death of the Beech was immediately due to fungal action. A study of the problems involved was turned over to the writer in 1929, and is still in progress under the direction of Dr. Faull, supported by the National Research Council of Canada and the Arnold Arboretum.

RANGE IN THE UNITED STATES

Since the scale had not, apparently, been reported in the United States, an examination was begun of Beeches in the metropolitan district about Boston. In November, 1929, a light infestation of what appeared to be the Beech scale was found on the native Beeches in the Arnold Arboretum. In December, a more severe attack was discovered on some Beeches sheltered by Hemlocks in the Boston city park at Jamaica Pond. Some of this material was sent

to Dr. E. M. Patch and to Dr. Harold Morrison, both of whom independently stated that the insect was *Cryptococcus fagi*. The search was continued in the vicinity of Boston and infestations were located in several other places within the city, also in adjacent Brookline, and in Middlesex County. In the spring of 1931, the presence of the Beech scale in metropolitan Boston came to the attention of the United States Entomological Laboratory, Forest Insects Division, at Melrose Highlands, and the survey was continued by their staff, with the result that several additional outbreaks were located, ranging in Massachusetts from Gloucester on the north to the Blue Hills in Milton on the south, and westwards to Belmont and Newton. On November 5, 1931, a heavy infestation was found in Liberty, Maine, by members of the Melrose Highlands Laboratory. The age of the Boston attack cannot be stated with certainty; but its severity in isolated places and the comments of gardeners indicate that the insect has been present for approximately ten years.

IMPORTANCE

It cannot be prognosticated how widespread or serious the scale is likely to become; but the general fatality of infested Beeches in Nova Scotia and New Brunswick resulting from fungal attack suggests a potential danger of the first importance. Slime fluxes are not infrequent on the infested trees in Massachusetts as they are in the Maritime Provinces, but these seem to be of only minor significance. The species of fungus responsible for the death of the Maritime beeches has not been found in Massachusetts although the writer has examined a large proportion of all the trees in the region known by him to be infested.

LIFE HISTORY OF *CRYPTOCOCCUS FAGI*

The life history of *Cryptococcus fagi* was studied in Germany by Rhumbler (1915, 1922). He found that oviposition occurs from the middle of June to the end of October. The motile form I larvae hatch after a month, or longer in cooler weather. They are slender, 0.24–0.33 mm. in length, pale yellow in color, and equipped with active legs and five-membered antennae. These crawlers roam about the bark, generally in an upward direction, until a suitable resting place is found in a crevice of the bark, on the lower side of branches, or under the curly-threaded canopy of preceding generations. The stylets are inserted into the bark, the body increases in size to 0.35–0.38 mm., the legs lose their ability to move, exudation of white threads begins, and the insect is fixed in position for the remainder of its life. This change into the form II larva occurs in

the late autumn or the following February. Between April and July the form II larvae molt and become the nymphal form III, whose body length at first is 0.38–0.4 mm., whose legs are lacking, and whose antennae are two-membered. A second molt occurs soon after, followed by development into the egg-laying females, circular in outline and 0.5–0.8 mm. in size. Winged forms and males are lacking. The females oviposit periodically through the late summer and early autumn and die with the coming of the frosts. The life-cycle is thus annual.

The development of *C. fagi* in eastern America coincides with that in Europe. In Nova Scotia and New Brunswick, however, hatching does not begin until about the end of July and the crawlers stop roaming by the end of September. In Boston the period of larval activity is somewhat longer. Local dissemination of the insect is effected by wind-carriage of the crawlers and of bits of wool containing eggs, and within a beech stand by the travelling of the crawlers over the ground from one tree to another.

CONTROL

The beech scale does not seem to be a serious pest unless accompanied by certain fungi. Although that danger is apparently not yet present in the eastern United States, the surest way to forestall the possibility is to eradicate the scale. Obviously when once an insect such as this one becomes widely established in the woodlands, as it has in the Maritime Provinces, eradication is a very serious problem. But in Massachusetts, with a range still limited in area and restricted largely to ornamental situations, control seems not only feasible but greatly to be desired.

With a view to selecting an easily obtainable and effective insecticide for New England use, preliminary tests were made in the late winter of 1931 with different strengths of commercial Sunoco Oil, home-made kerosene-soap emulsion, nicotine sulphate (Black Leaf 40), and lime-sulphur. The tests were made by soaking an infested area of bark with the aid of a hand spray gun and removing samples of the bark at once and at intervals of several days for microscopic examination. The efficacy of the various materials was determined by placing the bark on the stage of a binocular and gently raising individual nymphs from the bark with a needle so as not to injure them while thus forcibly withdrawing their stylets from the bark. They were then rolled over so that their ventral sides were uppermost. Those not killed by the insecticide indicated their vitality by waving the stylets above their bodies. Others, raised slightly, but not sufficiently to cause complete withdrawal of the stylets from

the bark, would wave their bodies about, pivoted only on the stylets. A sufficient number of nymphs was examined in this way from every bark sample so as to leave no doubt as to the effect of a particular treatment. The results of these preliminary tests are summarized in Table I.

TABLE I. PRELIMINARY TESTS WITH CONTACT INSECTICIDES FOR CONTROL OF THE BEECH SCALE

Material	Strength	Place	Effective	Partially Effective	Not Effective
Kerosene-soap emulsion	25%	Arnold Arboretum	*		
Kerosene-soap emulsion	25%	Jamaica Pond		*	
Sunoco Oil	1-25	Jamaica Pond		*	
Sunoco Oil	1-5	Middlesex Fells	*		
Black Leaf 40	1-50	Jamaica Pond			*
Black Leaf 40	1-50	Middlesex Fells		*	
Black Leaf 40	1-25	Middlesex Fells		*	
Black Leaf 40 plus Sunoco Oil	1-25 1-15	Middlesex Fells	*		
Lime-sulphur	app. 5° B.	Jamaica Pond			*

These results indicate that lime-sulphur and nicotine sulphate are not satisfactory materials but that Sunoco Oil and kerosene-soap emulsion are suitable.

Later in the spring of 1931 field tests were made with commercial equipment operated by regular park employees in the Arnold Arboretum, the Boston Parks, and the Middlesex Fells Reservation, using Sunoco Oil, kerosene-soap emulsion, and nicotine sulphate. The pertinent results of these tests are brought together in Table II.

It was concluded from these results that Sunoco Oil, 1-15, is the most satisfactory material. The critical factor in these tests seemed to be the ability of the operator to cover the entire surface of the tree with sufficient thoroughness so that the material wet the fluffy canopy protecting the insects and penetrated to their bodies. This was possible only with the oils. A few trees were also scrubbed with each of these materials, using a long pole with a scrub-brush screwed to one end. It was found that this method, when used with Sunoco Oil or kerosene-soap emulsion, was much the most thorough. But it is a difficult method and the labor and expense

involved make it applicable only in estates where a small number of valued shade trees are to be kept completely free of the scale.

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TABLE II. FIELD TESTS WITH CONTACT INSECTICIDES FOR CONTROL OF THE BEECH SCALE

Material	Strength	Place	Number of Infested Trees Sprayed	Number of These Trees Scale-Free ¹	% Control
Sunoco Oil	1-15	Arnold Arboretum	15	15	100
Kerosene-soap emulsion	25%	Willow Pond Road, Boston	18	12	66 $\frac{2}{3}$
Sunoco Oil, soap, and Black Leaf 40	1-10 $\frac{1}{2}$ pint per 40 gallons	Middlesex Fells	69	69	100
water Black Leaf 40 soap	50 gallons $\frac{1}{2}$ pint 2 $\frac{1}{2}$ lbs	Jamaica Pond, Boston	9	0	0

¹ Number of these trees on which no living scale could be found on careful examination of accessible parts with a hand-lens a month after spraying.

SUMMARY

The beech scale of Europe, present and spreading in eastern Canada for many years, has recently been found to be abundant on Beeches in the vicinity of Boston, Massachusetts, and has just been discovered in one locality in Maine. Beeches in eastern Canada are dying in vast quantities through the attacks of fungi which grow in scale-infested bark; but these fungi have not been found on Beeches in Massachusetts. The insect has an annual life-cycle; dissemination is effected by eggs and larvae during the summer and autumn. Experiments with contact insecticides point to the efficacy of thoroughly spraying ornamental trees with Sunoco Oil or kerosene-soap emulsion.

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